

Link Light Rail Operations and Maintenance Satellite Facility

Final Environmental Impact Statement

NOISE AND VIBRATION TECHNICAL REPORT

Appendix E2



NOISE AND VIBRATION TECHNICAL REPORT

SOUND TRANSIT LINK LIGHT RAIL OPERATIONS AND MAINTENANCE SATELLITE FACILITY

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Acronyms and Abbreviations

| | |
|---------------|---|
| ANSI | American National Standards Institute |
| BCC | Bellevue City Code |
| CFR | Code of Federal Regulations |
| dB | decibel |
| dBA | decibel with A-weighting |
| DNL | day-night equivalent sound level (see also Ldn) |
| DNR | Department of Natural Resources |
| EDNA | Environmental Designation for Noise Abatement |
| EIS | Environmental Impact Statement |
| EPA | U.S. Environmental Protection Agency |
| FAA | Federal Aviation Administration |
| FHWA | Federal Highway Administration |
| FTA | Federal Transit Administration |
| HUD | Department of Housing and Urban Development |
| HVAC | heating, ventilation, and air-conditioning |
| Hz | hertz |
| I-5 | Interstate 5 |
| in/sec | inches per second |
| Ldn | 24-hour, time-averaged, A-weighted sound level (day-night) |
| Leq | equivalent continuous sound level |
| LMC | Lynnwood Municipal Code |
| mph | miles per hour |
| NEPA | National Environmental Policy Act |
| NIST | National Institute of Standards and Technology |
| SEPA | State Environmental Policy Act |
| Sound Transit | Central Puget Sound Regional Transit Authority |
| SR | State Route |
| ST2 | Sound Transit 2: A Mass Transit Guide, The Regional Transit System Plan for Central Puget Sound |
| TPSS | Traction Power Substation |
| WAC | Washington Administrative Code |

1.1 Project Alternatives

Four build alternatives were identified by the Sound Transit Board for evaluation in the Sound Transit Link Light Rail Operations and Maintenance Satellite Facility (OMSF) Draft Environmental Impact Statement (EIS). The EIS discusses the potential environmental impacts that may result from construction and operation of the proposed project under each of these build alternatives. In addition, the potential environmental impacts that may result from the No Build Alternative, the conditions that would exist if the proposed project were not implemented, are also discussed to provide a baseline for comparing the potential impacts of the build alternatives.

Sound Transit and the Federal Transit Administration (FTA) published the Draft EIS for the proposed project on May 9, 2014, with a 45-day comment period. The Sound Transit Board considered the build alternatives analyzed in the Draft EIS and the public and agency comments received during the comment period. On July 24, 2014, the Sound Transit Board approved Motion M2014-51, identifying the BNSF Alternative as the Preferred Alternative and directed staff members to evaluate further potential design modifications for the Preferred Alternative in the Final EIS.

All four build alternatives would involve construction and operation of the following site features:

- An enclosed light rail vehicle (LRV) maintenance building containing service bays for maintaining LRVs that would include the following activities and equipment.
 - Exterior LRV washing area
 - Interior LRV cleaning area
 - General service, inspection, and repair bays
 - Wheel truing
 - Equipment and parts storage
 - Shipping and receiving
 - Electronics shop
 - Welding and fabrication shop
 - Brake and coupler shop
- Office space attached to the shop building containing the following items.
 - Individual offices and workspaces
 - Conference rooms
 - Training room
 - Fitness room
 - Lunch/break room

- Lockers
- Restrooms
- Track, switches, catenary power lines, a traction power substation, and signals to support movement of LRVs to and from the mainline and around the facility through the LRV maintenance building and LRV storage area.
- Lead track to provide access between the OMSF and light rail system mainline.

1.1.1 No Build Alternative

Under the No Build Alternative, an OMSF would not be built. The operations and maintenance support needs for the existing and currently planned and funded Link light rail system would be served by the existing Forest Street Operations and Maintenance Facility (OMF) south of downtown Seattle. The Forest Street OMF has the capacity to maintain up to 104 LRVs, 76 fewer than the minimum number of LRVs needed to operate the system at planned service levels.

1.1.2 Preferred Alternative

Under the Preferred Alternative, Sound Transit would construct the OMSF on property located between the Eastside Rail Corridor on the west and 120th Avenue NE on the east, south of SR 520 and north of NE 12th Street in the city of Bellevue. This site is approximately 28 acres, including 2 acres of the Eastside Rail Corridor that are now under Sound Transit ownership, and located along the adopted East Link revenue line northwest of the 120th Avenue NE Station. The OMSF development footprint on the site is approximately 21 acres, leaving approximately 6 acres for redevelopment. An additional one (1) acre at the northern end of the site is planned to be used for development of an interim trail. Infrastructure for the proposed project would occupy most of the site, leaving the southern portion available for other development.

The Sound Transit Board Motion M2014-51 directed staff members to prioritize and incorporate agency and community transit-oriented development (TOD) consistent with the Sound Transit TOD Policy (Resolution No. R2012-24). Since publication of the Draft EIS, the site design and the layout of the Preferred Alternative have been refined as follows.

1. The facility footprint area was reduced by approximately 9% (from 23 to 21 acres).
2. The OMSF buildings were moved to the north to allow more land for TOD at the southern portion of the site.
3. The OMSF footprint was set back an additional 25 feet from 120th Avenue NE.
4. The maintenance building location and configuration were revised to avoid building over an existing King County sanitary sewer trunk line.

In addition, the Preferred Alternative includes project elements identified during the Stakeholder Process which make the OMSF more compatible with the vision and policies of the *Bel-Red Subarea Plan* (City of Bellevue 2009). The *Bel-Red Subarea Plan* calls for concentrating TOD in station areas (i.e., station nodes), creating pedestrian and bicycle connectivity between light rail station areas and the future regional trail in the Eastside Rail Corridor, and restoring streams and open space as properties in the Bel-Red subarea are redeveloped. The Preferred Alternative includes the following elements that address these objectives.

1. Designing and building infrastructure onsite that would facilitate potential future development on or adjacent to the OMSF, such as utility stub-outs and a structural shear wall between the maintenance building and the wash-bay that would support building over this part of the facility in the future. Specific development proposals for property on or adjacent to the OMSF would undergo separate, project-level environmental review, land use approvals, and design review by others in coordination with the City of Bellevue.
2. In coordination with King County Metro, development of an interim trail in the Eastside Rail Corridor from the pedestrian connection between the Hospital Station and 116th Avenue N to SR 520. The interim trail would be approximately 10 feet wide, made of crushed gravel, and located on the existing railbed in the corridor. A similarly designed interim trail connection along the north side of the OMSF would follow an abandoned rail spur and would provide connectivity between the corridor and 120th Avenue NE. Finally, an interim trail would be developed in the landscaped frontage along 120th Avenue NE, to provide connectivity to the East Link 120th Avenue Station (Figure 2-4c).
3. The West Tributary of Kelsey Creek is located in the wetland complex north of the Preferred Alternative site, and flows in a pipe under and parallel to 120th Avenue NE for approximately 340 feet, before discharging to an open channel on the east side of 120th Avenue NE. The Preferred Alternative design would include a northern access driveway and a north interim trail connection to accommodate an approximate 65-foot-long fish-passable culvert. The creek could then be realigned and daylighted for approximately 350 feet when the City of Bellevue implements the planned realignment and improvements to 120th Avenue NE.

1.1.3 BNSF Modified Alternative

Under the BNSF Modified Alternative, Sound Transit would construct the OMSF on both sides of the Eastside Rail Corridor off of 120th Avenue NE on the east, south of SR 520 and north of NE 12th Street in the City of Bellevue. This site is located along the adopted East Link revenue line and is approximately 34 acres, including 2 acres of Eastside Rail Corridor now under Sound Transit ownership. The OMSF development footprint on the site is approximately 24 acres leaving approximately 8 acres for future redevelopment. The storage tracks would be located on the western portion of the site, west of the rail corridor. Other OMSF facilities would be located adjacent to the east side of the rail corridor, leaving the frontage area along 120th Avenue NE available for other development. The design acknowledges the railbanked status of the Eastside Rail Corridor by allowing sufficient width and vertical clearances to accommodate a future trail and future freight or passenger rail use of the corridor.

1.1.4 SR 520 Alternative

Under the SR 520 Alternative, Sound Transit would construct the OMSF south of SR 520 and north of Northup Way/NE 20th Street, east of 130th Avenue NE and west of 140th Avenue NE in the City of Bellevue. This site is located along the adopted East Link revenue line and is approximately 25 acres. The OMSF development footprint encompasses the entire site, leaving no substantial area for redevelopment. The configuration of buildings under this alternative would vary from the other alternatives in that the operations offices would be in a separate building to the west of the LRV maintenance shops, and the LRV covered wash and service bay would be in a separate building east of the LRV maintenance shops.

1.1.5 Lynnwood Alternative

Under the Lynnwood Alternative, Sound Transit would construct the OMSF north of I-5 and east of 52nd Avenue/W Cedar Valley Road in the city of Lynnwood. The OMSF footprint for the Lynnwood Alternative would require approximately 24 acres of land. Approximately 41 acres would need to be acquired, given existing parcel boundaries, and approximately 4 acres are designated as wetlands and wetland buffers leaving approximately 13 acres for redevelopment. The Lynnwood Link Extension would be located along the Lynnwood Alternative site for the OMSF. In November 2013, the Sound Transit Board identified Lynnwood Link Extension Alternative C3 with modifications as the Preferred Alternative per Motion M2013-96 for evaluation in the *Lynnwood Link Extension Final EIS* (Sound Transit 2015). On April 23, 2015, The Sound Transit Board selected the project to be built by adoption of M2015-33.

The Lynnwood Alternative for the OMSF also includes LRV storage, operator report facilities, and interior cleaning functions for up to 32 LRVs at a separate location (referred to as the BNSF Storage Tracks, a component of the Lynnwood Alternative). The BNSF Storage Tracks would be located north of NE 12th Street and south of SR 520 in the city of Bellevue, within the Sound Transit-owned portion of the Eastside Rail Corridor and on an adjacent property located immediately east of the Eastside Rail Corridor to provide morning service to the Eastside. The design acknowledges the railbanked status of the Eastside Rail Corridor by allowing sufficient width to accommodate a future trail and future freight or passenger rail use of the corridor.

1.2 Analysis Requirements

This noise and vibration analysis of the proposed OMSF was prepared as required by the FTA for any federal funded component of a major transportation project. The analysis was performed using the methods provided in the *Transit Noise and Vibration Impact Assessment manual* (Federal Transit Administration 2006) (hereafter referred to as the FTA manual) and is part of an environmental impact statement (EIS) for the proposed project.

Chapter 2

Introduction to Noise and Vibration

The following sections include background information on noise and vibration. This information is necessary to understand the noise and vibration impact criteria provided in Chapter 3, *Impact Criteria*, along with the results of the noise and vibration impact assessment and mitigation measures.

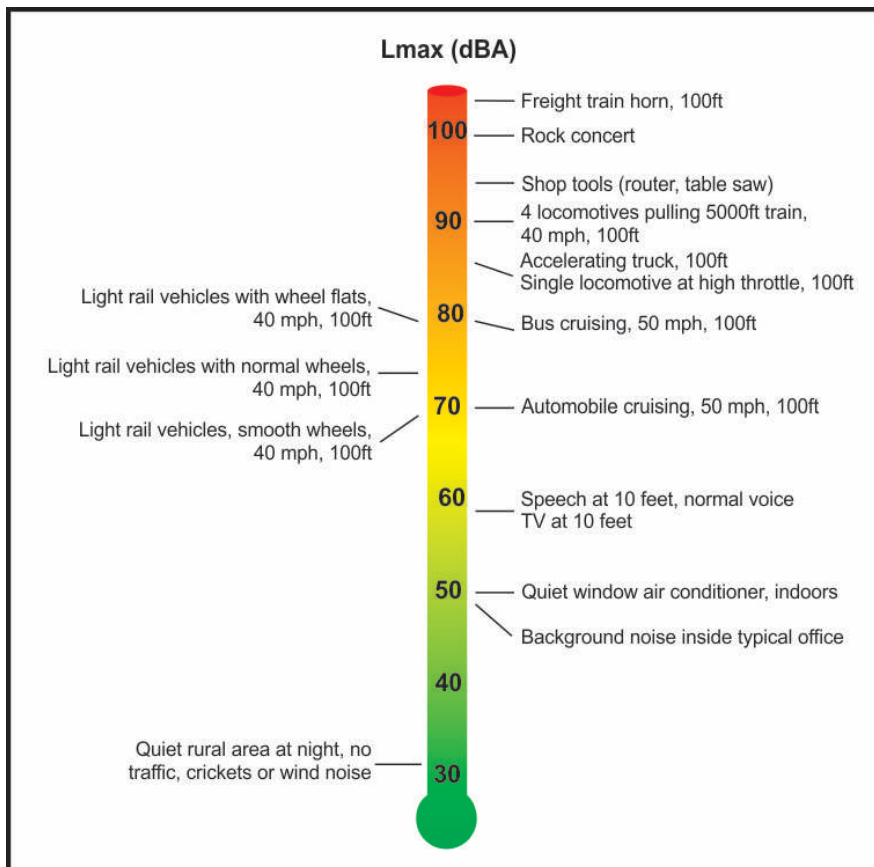
2.1 Introduction to Noise

What we hear as sound is a series of continuous air pressure fluctuations superimposed on the atmospheric pressure that surrounds us. The amplitude of fluctuation is related to the energy carried in a sound wave; the greater the amplitude, the greater the energy and the louder the sound. The full range of sound pressures encountered in the world is so great that it is more convenient to compress the range by using a logarithmic scale, resulting in the fundamental descriptor used in acoustics, the sound pressure level, in decibels (dB). When sounds are unpleasant, unwanted, or disturbingly loud, we tend to classify them as noise.

Another aspect of sound is the quality described as its pitch. Pitch is established by frequency, which is a measure of how rapidly a sound wave fluctuates as measured in cycles per second or Hertz (Hz). Most sounds are a composite of many individual frequencies. When a sound is analyzed, its energy content at individual frequencies is displayed over the frequency range of interest, usually the range of human audibility, from about 20 Hz to about 20,000 Hz. This display is called a frequency spectrum.

Sound is measured using a sound level meter with a microphone designed to respond accurately to all audible frequencies. The human hearing system does not respond equally to all frequencies. Low frequency sounds below about 400 Hz are progressively and severely attenuated, as are high frequencies above 10,000 Hz. To approximate the way humans interpret sound, a filter circuit with frequency characteristics similar to the human hearing mechanism is built into sound level meters. Measurements with this filter enacted are called A-Weighted Sound Levels (dBA). Community noise is usually characterized in terms of the A-weighted sound level.

Figure 2-1 illustrates the A-weighted levels of common sounds. When sounds exceed 110 dBA, there is a potential for hearing damage, even with relatively short exposures. In quiet suburban areas far from major freeways, the noise levels during the late night hours will drop to about 30 dBA. Outdoor noise levels lower than this only occur in isolated areas where there is a minimum of natural noises such as leaves blowing in the wind, crickets, or flowing water.

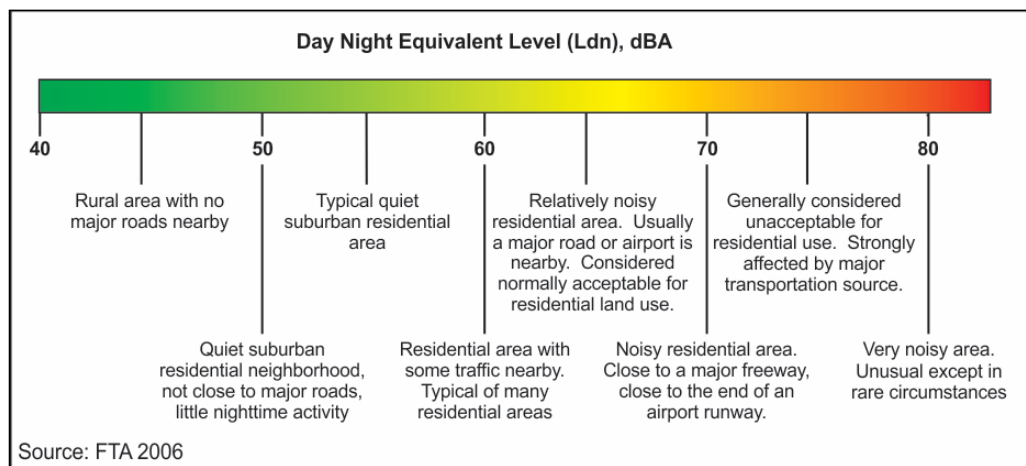
Figure 2-1. Typical A-Weighted Sound Levels

Another characteristic of environmental noise is that it is constantly changing. The noise level increase when a train passes is an example of a short-term change. The lower average noise levels during nighttime hours, when human activities are at a minimum, and the higher noise levels during daytime hours are daily patterns of noise level fluctuation. The instantaneous A-weighted sound level is insufficient to describe the overall acoustic "environment." Thus, it is common practice to condense the fluctuating noise levels into a single number, called the "equivalent" sound level (Leq). Leq can be thought of as the steady sound level that represents the same sound energy as the varying sound levels over a specified time period (typically 1 hour or 24 hours). Often the Leq values over a 24-hour period are used to calculate cumulative noise exposure in terms of the Day-Night Equivalent Sound Level (L_{dn}, also abbreviated DNL), which is defined as the 24-hour Leq but with a 10-dB penalty assessed to noise events occurring at night (defined as 10:00 p.m. to 7:00 a.m.). The effect of this penalty is that any event during the nighttime hours is equivalent to ten events during the daytime hours. This strongly weights L_{dn} toward nighttime noise to reflect the fact that most people are more easily annoyed by noise during the nighttime hours, when background noise is lower and most people are sleeping.

Environmental impact assessments for high capacity transit projects in the United States typically use L_{dn} to describe the community noise environment. Studies of community response to a wide variety of noises indicate that L_{dn} is a good measure of noise environment. Efforts to derive measures that are better correlated to community response have not been successful, although there are still efforts in the acoustical community to develop improved measures.

Figure 2-2 defines typical community noise levels in terms of Ldn. Most urban and suburban neighborhoods will be in the range of Ldn 50 to 70 dBA. An Ldn of 70 dBA is a relatively noisy environment that might be found at buildings on a busy surface street, close to a freeway or near a busy airport. It would usually be considered unacceptable for residential land use without special measures taken to enhance outdoor-indoor sound insulation. Residential neighborhoods that are not close to major sound sources will usually be in the range of Ldn 55 to 60 dBA. If there is a freeway or moderately busy arterial nearby, or any nighttime noise, Ldn is usually in the range of 60 to 65 dBA. In recent times, many urban developments have combined retail, light commercial and other non-residential uses with residential uses in a mixed-use environment. Because of these mixed-use developments, ambient noise levels in some urban environments may be slightly higher than the levels provided in Figure 2-2.

Figure 2-2. Typical Ldn Levels



2.1.1 General Acoustical Rules

The following list contains some general rules for community noise:

- A 3 dB change is the minimum most people will notice in most environments.
- Under free-field conditions, where there are no reflections or additional attenuations, a point sound source is known to decrease at a rate of 6 dB for each doubling of distance. This is commonly known as the inverse square law. For example, a sound level of 70 dB at a distance of 100 feet would decrease to 64 dB at 200 feet. However, traffic on roadways and LRVs are considered line sources, and reduce at approximately 3 dB for each doubling of distance.
- Sounds such as sirens, bells, and horns are more noticeable than broadband noise sources, such as traffic.
- A 10 dB increase in sound level is perceived as an approximate doubling of the loudness of the sound and represents a substantial change in loudness.
- An important factor to recognize is that noise is measured on a decibel scale, and combining two noises is not achieved by simple addition. For example, combining two 60 dBA noises does not give 120 dBA (which is near the pain threshold), but yields 63 dBA, which is lower than the volume at which most people listen to their TVs.

2.2 Introduction to Vibration

Ground-borne vibration consists of oscillatory waves that propagate from the source through the ground to adjacent buildings. On steel-wheel/steel-rail train systems, ground-borne vibration is created by the interaction of the steel wheels rolling on the steel rails. Although the vibration is sometimes noticeable outdoors, it is almost exclusively an indoor problem. Additionally, trains operating at the build alternative sites would not produce sufficient vibration even to cause minor cosmetic damage to nearby buildings.

The primary concern is that the vibration and radiated noise can be intrusive and annoying to building occupants. The building vibration caused by ground-borne vibration may be perceived as motion of building surfaces; rattling of windows, items on shelves, or pictures hanging on walls; or as a low-frequency rumbling noise, which is referred to as ground-borne noise. Factors that influence the amplitudes of ground-borne vibration include vehicle suspension parameters, condition of the wheels and rails, type of track, track support system, type of building foundation, and the properties of the soil and rock layers through which the vibration propagates. Use of continuously welded rails eliminates wheel impacts at rail joints and results in notably lower vibration levels than with jointed rails.

Ground-borne vibration is not a widespread environmental problem, and it is generally limited to localized areas near rail systems, construction sites, and some industrial operations. Road traffic rarely creates perceptible ground-borne vibration except when there are bumps, potholes or other discontinuities in the road surface. When traffic causes phenomena such as rattling of windows, the cause is more likely to be “acoustic excitation” rather than ground-borne vibration. The unusual situations where traffic or other existing sources are causing intrusive vibration can be an indication of geologic conditions that would result in higher than normal levels of train vibration.

Low-frequency noise caused by sound radiated from vibrating room surfaces is referred to as ground-borne noise. Ground-borne vibration and ground-borne noise are really the same phenomenon; they only differ in the manner in which they are perceived by the building occupants. It is extremely rare for train-generated ground-borne vibration to be of sufficient amplitude to cause even minor cosmetic building damage. The main concern is that building occupants will find the vibration intrusive, particularly late at night or early in the morning when they are trying to sleep. Although all vehicular traffic causes ground-borne vibration, the vibration is not usually perceptible because of the vibration isolation characteristics of the pneumatic tires and the suspension systems.

Vibration is an oscillatory motion that can be described in terms of the displacement, velocity, or acceleration of the oscillations. Ground-borne vibration is usually characterized in terms of the vibration velocity because, over the frequency range relevant to ground-borne vibration (about 1 to 200 Hz); both human and building response tends to be more proportional to velocity than either displacement or acceleration. Vibration velocity is usually given in terms of either inches per second or decibels.

The following equation defines the relationship between vibration velocity in inches per second and decibels.

$$Lv = 20 \times \log (V/V_{ref});$$

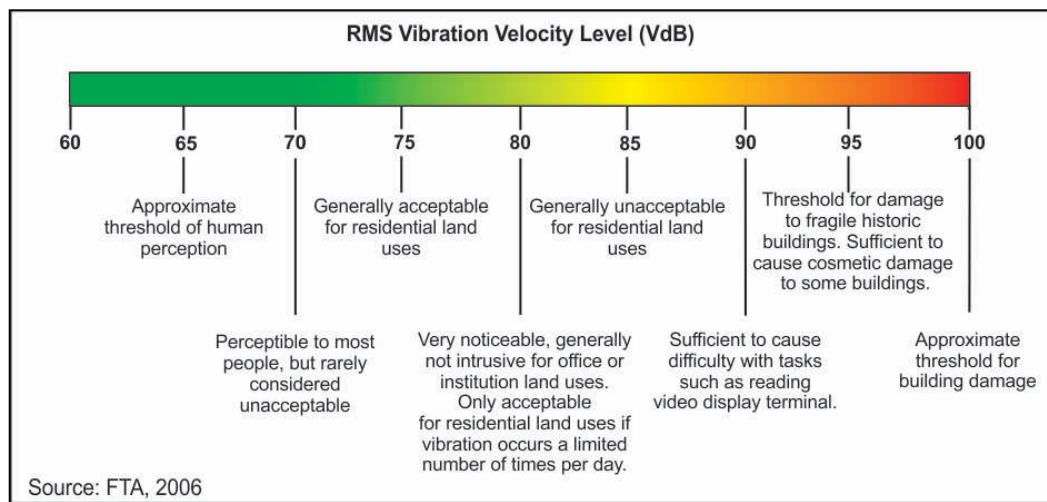
where V is the velocity amplitude in inches/second, Vref is 10⁻⁶ inches/second, Lv is the velocity level in decibels.

Vibration decibels (VdB) are abbreviated in this report, to minimize confusion with sound decibels.

Train vibration is virtually always characterized in terms of the root-mean-square (RMS) amplitude. RMS is a widely used but sometimes confusing method of characterizing vibration and other oscillating phenomena. It represents the average energy over a short time interval; typically, a one second interval is used to evaluate human response to vibration. RMS vibration velocity is considered the best available measure of potential human annoyance from ground-borne vibration.

Figure 2-3 gives a general idea of human and building response to different levels of vibration. Existing background building vibration is usually in the range of 40 to 50 VdB, which is well below the range of human perception. Although the perceptibility threshold is about 65 VdB, human response to vibration is usually not bothersome unless the RMS vibration velocity level exceeds 70 to 75 VdB. This is a typical level 50 feet from a rapid transit or light rail system. Buses and trucks rarely create vibration that exceeds 70 VdB unless there are large bumps or potholes in the road.

Figure 2-3. Typical RMS Vibration Levels



Several different criteria were evaluated for applicability to the OMSF noise and vibration analysis. These include the FTA manual and local criteria from the Cities of Bellevue and Lynnwood. As required by the FTA, if the light rail project includes any modifications to existing roadways that change the vertical or horizontal alignment, add new lanes, or includes a new roadway, the project must consider potential traffic noise impacts in accordance with the Federal Highway Administration (FHWA) standards and regulations. No such roadway modifications are planned as part of the proposed project, and therefore, no discussion of the FHWA standards is necessary. All other applicable noise and vibration criteria and methods used for the noise studies are provided in the following sections.

3.1 FTA Noise Criteria

Transit noise impacts for this project are determined based on the criteria defined in the FTA guidance manual. The FTA noise impact criteria are based on documented research on community reaction to noise. The criteria for noise impacts is based on a sliding scale, which uses the existing noise levels as a basis for setting the actual impact level. Although more transit noise is allowed in neighborhoods with high levels of existing noise, as the existing noise levels increase, a smaller increase in the total noise exposure is allowed when compared to areas with lower existing noise levels. The FTA noise impact criteria also groups noise-sensitive land uses into the following three categories.

- **Category 1.** Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included in this category are recording studios and concert halls. Category 1 land use is evaluated using the exterior peak-hour Leq.
- **Category 2.** Residences and buildings where people normally sleep. This category includes homes, hospitals, and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance. Category 2 land use is evaluated using the exterior 24-hour Ldn.
- **Category 3.** Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds, and recreational facilities are also considered to be in this category. Certain historical sites and parks are also included. Category 3 land use is evaluated using the exterior peak-hour Leq.

The FTA guidance manual provides details on how parks are analyzed for noise in Chapter 3, Section 2, *Application of Noise Impact Criteria*, of the manual. The FTA assumes that parks are a special case, and how they are used and where they are located should be considered when considering whether or not a particular park, or an area in a park, is considered noise-sensitive. Parks that are used for outdoor recreation are typically not considered noise-sensitive. This includes

parks with baseball diamonds, soccer fields, basketball courts, football fields, and other active recreation areas.

Parks that are noise-sensitive would be those where quiet is an essential element in their intended purpose or places where it is important to avoid interference with activities such as speech, meditation, and reading. The existing noise levels at a park can provide some indication of the sensitivity of its use.

All parks along the project corridor were evaluated for consideration under the FTA criteria. Based on the park locations and existing noise levels, no parks, except for Scriber Creek Park, met the requirements for noise sensitivity under the FTA Category 3 criteria. Hours of operation are considered when performing a noise analysis on a park. The City of Lynnwood website has information on parks, and states that this park, along with all other Lynnwood parks, is only open during daylight hours (dusk to dawn).

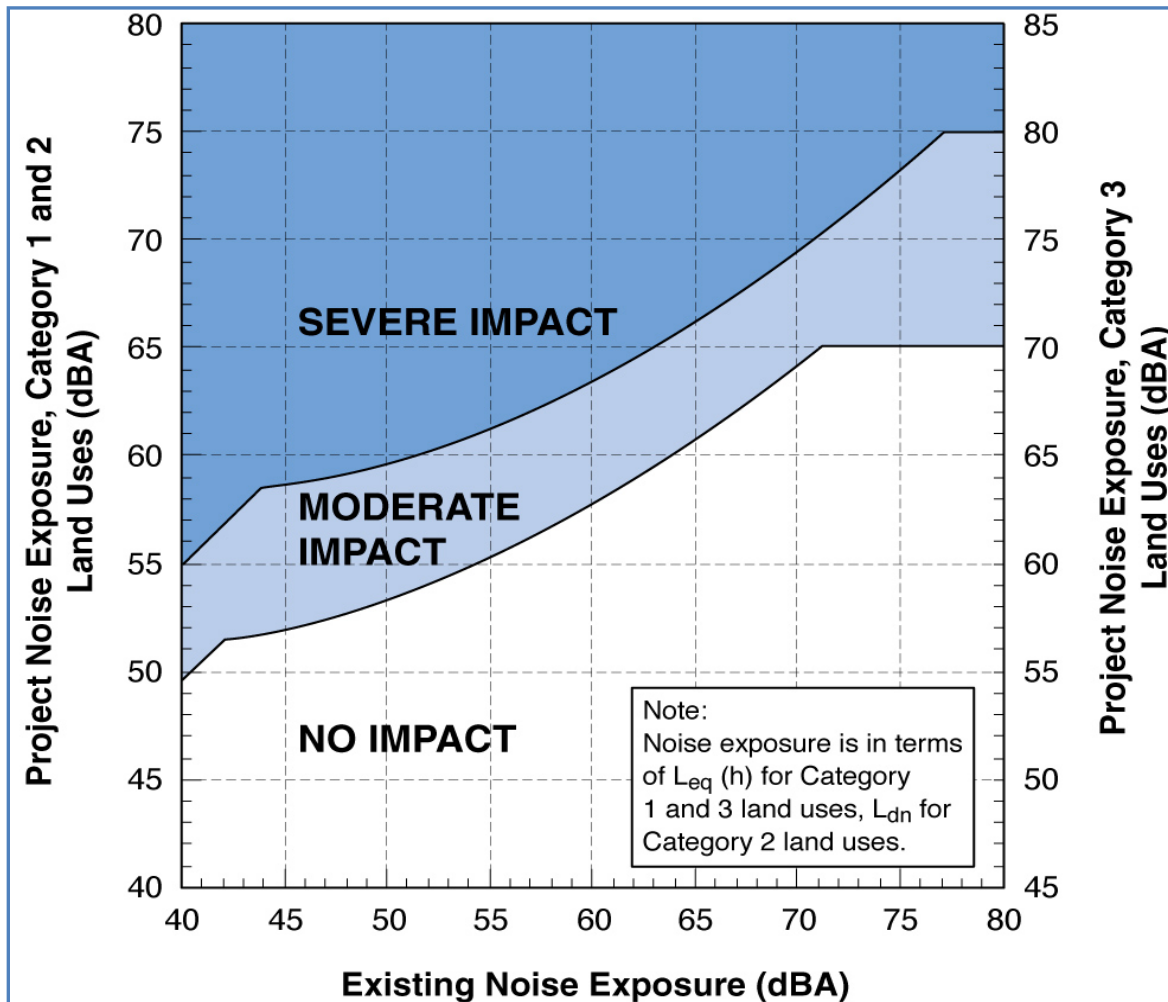
The Ldn is used to characterize noise exposure for residential areas (Category 2). For other noise-sensitive land uses, such as outdoor amphitheaters and school buildings (Categories 1 and 3), the maximum 1-hour Leq during the facility's operating period is used. There are no noise impact criteria for most commercial and industrial land uses.

There are two levels of impact included in the FTA criteria: severe and moderate, interpreted as follows:

- **Severe Impact.** Project-generated noise in the severe impact range can be expected to cause a large percentage of people to be highly annoyed by the new noise and represents the most compelling need for mitigation. Noise mitigation will normally be specified for severe impact areas unless there are truly extenuating circumstances that prevent it.
- **Moderate Impact.** In this range of noise impact, the change in the cumulative noise level is noticeable to most people but may not be sufficient to cause strong, adverse reactions from the community. In this transitional area, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These factors include the existing level, the projected level of increase over existing noise levels, the types and numbers of noise-sensitive land uses affected, the noise sensitivity of the properties, the effectiveness of the mitigation measures, community views, and the cost of mitigating noise to more acceptable levels.

The FTA noise impact criteria are summarized in graphical form in Figure 3-1, which shows the existing noise exposure and the additional noise exposure from the transit project that would cause either moderate or severe impact. The future noise exposure would be the combination of the existing noise exposure and the additional noise exposure caused by the transit project.

Figure 3-1. FTA Noise Impact Criteria



Source: Federal Transit Administration 2006.

3.1.1 FTA Construction Noise

Although the FTA does not specify standardized criteria for construction noise, it does provide guidance on reasonable L_{eq} noise levels based on an 8-hour L_{eq} ($L_{eq}(8)$) for land use type and time of day. For residential land uses, FTA recommends that noise levels not exceed 80 dBA $L_{eq}(8)$ during daytime hours or 70 dBA during nighttime hours. For commercial uses, that recommendation is increased to 85 dBA $L_{eq}(8)$ during both daytime and nighttime hours. Industrial land uses have daytime and nighttime recommended construction noise limits of 90 dBA $L_{eq}(8)$.

3.2 FTA Vibration Criteria

FTA has developed impact criteria for acceptable levels of ground-borne noise and vibration. Ground-borne noise is sometimes associated with subterranean transit projects and is not a concern for the proposed project because the alignment will be elevated or at-grade.

Experience with ground-borne vibration from rail systems and other common vibration sources suggests the following.

- Ground-borne vibration from transit trains should be characterized in terms of the RMS vibration velocity amplitude. A one-second RMS time constant is assumed. This is in contrast to vibration from blasting and other construction procedures that have the potential of causing building damage. When looking at the potential for building damage, ground-borne vibration is usually expressed in terms of the peak particle velocity (PPV).
- The threshold of vibration perception for most humans is around 65 VdB. Levels in the 70 to 75 VdB range are often noticeable but acceptable, and levels greater than 80 VdB are often considered unacceptable.
- For an operations and maintenance facility, which has train movement throughout the day, evening and nighttime hours, the FTA limit for acceptable levels of residential ground-borne vibration is 72 VdB.
- For human annoyance, there is some relationship between the number of events and the degree of annoyance caused by the vibration. It is intuitive to expect that more frequent vibration events, or events that last longer, will be more annoying to building occupants. Because of the limited amount of information available, there is no clear basis for defining this tradeoff. To account for the fact that most commuter rail systems have fewer daily operations than the typical urban transit line, the criteria in the FTA Guidance Manual (ref. 1) include an 8 VdB higher impact threshold if there are fewer than 70 trains per day.
- Ground-borne vibration from any type of train operations will rarely be high enough to cause any sort of building damage, even minor cosmetic damage. The only real concern is that the vibration will be intrusive to building occupants or interfere with vibration-sensitive equipment.

The FTA assigns sensitive land uses to the following three categories.

- **Vibration Category 1: High Sensitivity.** This category includes buildings where low ambient vibration is essential for the interior operations in the building. Vibration levels may be below the level of human perception. Typical land uses covered by Category 1 are vibration-sensitive research and manufacturing, hospitals with vibration-sensitive equipment, and university research operations. The degree of sensitivity to vibration will depend on the specific equipment that will be affected by the vibration. Equipment such as electron microscopes and high-resolution lithographic equipment can be very sensitive to vibration, and even normal optical microscopes will sometimes be difficult to use when vibration is well below the human annoyance level. Manufacturing of computer chips is an example of a vibration-sensitive process.
- **Vibration Category 2: Residential.** This category includes residences and buildings where people normally sleep, including private dwellings, hospitals, and hotels where nighttime sensitivity is assumed to be of utmost importance. It is common practice to also use this category as a standard for some special uses such as auditoriums or theaters.
- **Vibration Category 3: Institutional.** This category includes land uses with primarily daytime use including schools, churches, and other institutions and quiet offices that do not have vibration-sensitive equipment. Offices in buildings primarily for industrial use are not included in this category.

Table 3-1 summarizes the FTA impact criteria for ground-borne vibration. These criteria are based on previous standards, criteria, and design goals, including ANSI S3.29 and the noise and vibration guidelines of the American Public Transit Association. Land use categories are described in the following paragraph.

Table 3-1. FTA Vibration Impact Criteria for Frequent Events^a

| Land Use Category | Category Comment | Ground-borne Vibration (VdB re 1 micro in/sec) |
|-------------------|-------------------------------------|--|
| 1 | Low interior vibration is essential | 65 |
| 2 | Residential and sleep | 72 |
| 3 | Institutional and daytime | 75 |
| — ^b | Concert hall, TV/Recording Studio | 65 |
| — ^b | Auditorium | 72 |
| — ^b | Theatre | 72 |
| — ^b | Office Use for Detailed Analysis | 84 |

^a *Frequent* is defined as greater than or equal to 70 events per day.

^b Special buildings and office spaces do not fall into any FTA categories.

Source: Federal Transit Administration 2006.

The 72 VdB level for frequent light rail passbys is the most stringent vibration criterion used for high-capacity vibration analysis at residential land uses. In addition, some land use activities are more sensitive to vibration than other uses (Table 3-1). For example, certain research and fabrication facilities, television and recording studios, and concert halls are more vibration sensitive than residences and buildings where people normally sleep, which are more sensitive than institutional land uses with primarily daytime use. No special buildings (e.g., television and recording studios, concert halls) have been identified near any of the build alternative sites. At those locations where vibration-sensitive equipment is used, such as hospitals, medical facilities, and high-tech manufacturing and testing sites, there may be the potential for additional or more severe ground-vibration impacts from transit operations. The only facility in that category is the Seattle Children's Hospital: Bellevue Clinic and Surgery Center, located near the Preferred Alternative and the BNSF Modified Alternative sites, which was evaluated using the FTA Category 1 vibration criteria.

3.3 Construction Vibration

The parameter normally used to quantify and assess construction vibration is the peak particle velocity (PPV). PPV is the maximum velocity recorded during a particular event, such as the hammering of a jack hammer. Table 3-2 summarizes the levels of PPV vibration and the usual effect on people and buildings. The vibration levels are also presented in terms of VdB. The vibration levels in VdB were derived assuming a reference factor of 1 micro-inch per second and a crest factor of 4 (representing a PPV-RMS difference of 12 VdB). Note, however, that there is a considerable variation in reported ground vibration levels from construction activities due to the wide range of soil conditions possible.

Table 3-2. Effects of Construction Vibration

| Peak Particle Velocity (in/sec) | Vibration levels in VdB | Effects on Humans | Effects on Buildings |
|---|--------------------------------|--|---|
| < 0.005 | < 62 | Imperceptible | No effect on buildings |
| 0.005–0.015 | 62–72 | Barely perceptible | No effect on buildings |
| 0.02–0.05 | 74–82 | Level at which continuous vibrations begin to annoy in buildings | No effect on buildings |
| 0.1–0.5 | 88–102 | Vibrations considered unacceptable for people exposed to continuous or long-term vibration | Minimal potential for damage to weak or sensitive structures |
| 0.5–1.0 | 102–108 | Vibrations considered bothersome by most people, however tolerable if short-term in length | Threshold at which there is a risk of architectural damage to buildings with plastered ceilings and walls. Some risk to ancient monuments and ruins. |
| 1.0–2.0 | 108–114 | Vibrations considered unpleasant by most people | U.S. Bureau of Mines data indicates that blasting vibration in this range will not harm most buildings. Most construction vibration limits are in this range. |
| > 3.0 | > 117 | Vibration is unpleasant | Potential for architectural damage and possible minor structural damage |
| Source: FTA, 2006, U.S and Transportation Related Earth-borne Vibrations. Caltrans, Technical Advisory, TAV-02-01-R9601, February 2002. | | | |

There are no specific construction related vibration regulations or criteria. The U.S. Department of Transportation (USDOT) has guidelines for vibration levels from construction related to their activities, and recommends that the maximum peak-particle-velocity levels remain below 0.05 inch per second at the nearest structures. Vibration levels above 0.5 inch per second have the potential to cause architectural damage to normal dwellings. USDOT also states that vibration levels above 0.015 inch per second are sometimes perceptible to people, and the level at which vibration becomes annoying to people is 0.64 inch per second.

3.4 Local Noise Control Ordinances

This technical report has been prepared to meet the requirements of the FTA manual. Under the FTA guidance for federally funded, high-capacity transportation projects, the noise analysis must be performed in accordance with the FTA guidelines. In addition to meeting the FTA noise impact criteria, maintenance facilities and other related ancillary facilities must also consider any state, city or local noise ordinances and standards that are applicable to the project. Both the Cities of Bellevue and Lynnwood have adopted local noise ordinances.

In Washington Administrative Code (WAC) 173-60, the Washington State Department of Ecology (Ecology) has adopted Maximum Environmental Noise Levels for residential, commercial, industrial, and construction areas. However, WAC 173-60-110 states the following.

The department conceives the function of noise abatement and control to be primarily the role of local government and intends actively to encourage local government to adopt measures for

noise abatement and control. Wherever such measures are made effective and are being actively enforced, the department does not intend to engage directly in enforcement activities.

As a result, only the noise abatement and control ordinances of the Cities of Bellevue and Lynnwood are used for this noise analysis. The ordinances are described below.

3.4.1 City of Bellevue Noise Control Ordinance

The City of Bellevue regulates noise pursuant to Chapter 9.18 of the Bellevue City Code (BCC), Noise Control. The City of Bellevue defines three environmental designations for noise abatement (EDNA), which are based on the land use districts listed in the City of Bellevue Land Use Code (BCC 9.18.025). The land use districts classified under each EDNA are listed in Table 3-3 by their designated code.

Table 3-3. City of Bellevue EDNA Land Use Designations

| Property Producing Noise (EDNA) | Land Use Districts |
|---------------------------------|---|
| Class A | R-1, R-1.8, R-2.5, R-3.5, R-4, R-5, R-7.5, R-10, R-15, R-20, R-30 |
| Class B | PO, O, OLB, OLB-OS, NB, CB, DNTN-O-1, DNTN-O-2, DNTN-MU, DNTN-R, DNTN-OB, DNTN-OLB, F1, F2, F3, MI, BR-R, BR-MO, BR-MO-1, BR-OR, BR-OR-1, BR-OR-2, BR-RC-1, BR-RC-2, BR-RC-3, BR-CR, BR-ORT |
| Class C | LI, GC, BR-GC |

BCC 9.18 also defines the maximum permissible environmental noise level from one EDNA to another EDNA (BCC 9.18.030). For example, noise generated by an EDNA Class C property must be 60 dBA or less at the closest EDNA Class A (residential areas) property line, 65 dBA or less at the closest EDNA Class B (commercial and mixed-use areas), and 70 dBA or less at the closest EDNA Class C (industrial and some commercial areas). These maximum permissible environmental noise levels are summarized in Table 3-4.

Table 3-4. City of Bellevue Maximum Permissible Noise Levels

| Property Producing Noise (EDNA) | Maximum Permissible Sound Level (dBA) Property Receiving Noise EDNA | | |
|---------------------------------|--|--------------|--------------|
| | Class A EDNA | Class B EDNA | Class C EDNA |
| Class A | 55 | 57 | 60 |
| Class B | 57 | 60 | 65 |
| Class C | 60 | 65 | 70 |

Between 10 p.m. and 7 a.m., the maximum permissible levels shown in Table 3-4 are reduced by 10 dBA for receiving properties in Class A EDNAs. Therefore, using the above example, the noise generated from an EDNA Class C property must be less than 50 dBA at the closest residential property line (EDNA Class A) between the hours of 10 p.m. and 7 a.m.

Sounds created by bells, chimes, and carillons that do not operate continuously for more than 5 minutes in any 1 hour are exempt from the maximum permissible environmental noise level limitations between the hours of 7 a.m. and 10 p.m. on weekdays and 9 a.m. and 10 p.m. on weekends if the receiving property is located in a Class A EDNA (BCC 9.18.020.B).

Sounds created by construction and emanating from construction sites are also exempt from the maximum permissible environmental noise level limitations described above between 7 a.m. and

6 p.m. on weekdays and 9 a.m. and 6 p.m. on Saturdays that are not legal holidays (BCC 9.18.020.C). Construction during nighttime hours (between 6 p.m. and 7 a.m. on weekdays, and between 6 p.m. and 9 a.m. on Saturdays) or on Sundays or legal holidays is required to meet the City's noise level limitations, as given in Table 3-4, unless a construction noise permit for expanded hours is received from the City. The City of Bellevue also has a 5 dB penalty for impulsive or pure tone noise sources for any receiving property.

3.4.2 City of Lynnwood Noise Control Ordinance

The City of Lynnwood regulates noise pursuant to Chapter 10.12 of the Lynnwood Municipal Code (LMC), Noise. The City of Lynnwood, using a method similar to that of the City of Bellevue, defines three EDNA designations and assigns zoning designations to each EDNA (LMC 10.12.400.B). The land use districts classified under each EDNA are listed in Table 3-5 by their designated code.

Table 3-5. City of Lynnwood EDNA Land Use Designations

| Property Producing Noise (EDNA) | Land Use Districts |
|--|---|
| Class A | RS-8, RS-7, RS-4, P-1, RML, RMM, RMH, MHP |
| Class B | B-2, B-3, PCD, B-1, CG, PRC, CC-C, CC-W, CC-N, MU, CDM, HMU |
| Class C | BTP, LI |

LMC 10.12 also defines the maximum permissible environmental noise level from one EDNA to another EDNA (LMC 10.12.500). These maximum permissible environmental noise levels are the same as those used in the City of Bellevue and summarized in Table 3-6.

Table 3-6. City of Lynnwood Maximum Permissible Noise Levels

| Property Producing Noise (EDNA) | Maximum Permissible Sound Level (dBA) Property Receiving Noise EDNA | | |
|--|--|---------------------|---------------------|
| | Class A EDNA | Class B EDNA | Class C EDNA |
| Class A | 55 | 57 | 60 |
| Class B | 57 | 60 | 65 |
| Class C | 60 | 65 | 70 |

Between 10 p.m. and 7 a.m., the maximum permissible levels shown in Table 3-6 are reduced by 10 dBA for receiving properties in Class A EDNAs. In addition, LMC 17.05.070, Environmental Health, authorizes a responsible official to “require applicants for city permits to provide documentation by a qualified consultant that the project will not exceed noise standards or violate nuisance regulations pertaining to noise, and provide recommendations from such a consultant as to how noise can be minimized. The responsible official is authorized to condition or deny projects that would violate state and local standards.”

Sounds that are exempt at all times from the maximum permissible sound levels include sounds created by warning devices that do not operate continuously for more than 5 minutes as well as bells, chimes, and carillons (LMC 10.12.500(F)(4)).

Sounds originating from construction sites as a result of construction activity are exempt every day of the week from the City of Lynnwood environmental noise level requirements, at all times in Class B and C EDNAs, and between 7 a.m. and 10 p.m. in Class A EDNAs (LMC 10.12.500(E)). In

addition, LMC 10.12.500(G) states “Nothing in these exemptions is intended to preclude the community development director from requiring installation of the best available noise abatement technology consistent with economic feasibility.”

The LMC does not address construction noise variances; however, any construction noise that may exceed the LMC between the hours of 7 a.m. and 10 p.m. at a Class A EDNA would be required to obtain a permit from the City of Lynnwood.

Chapter 4

Existing Land Use and Noise Levels

This chapter provides a summary of the existing land use and existing noise environment near the build alternative sites. For the purpose of defining land use, the FTA categories provided in Chapter 3, Section 3.1, *FTA Noise Criteria*, were used as the primary descriptor. EDNA classifications established by city codes (Sections 3.4.1, *City of Bellevue Noise Control Ordinance*, and 3.4.2, *City of Lynnwood Noise Control Ordinance*) are used to determine compliance with the local noise control ordinances of the Cities of Bellevue and Lynnwood.

Under the FTA criteria, the noise impact is based on the existing noise levels, and therefore ambient noise monitoring was required. The monitoring was used to establish the existing noise environment at land uses near the site. Impacts under the local regulations from the Cities of Bellevue and Lynnwood are property line noise limits that are based on the EDNA classifications of the noise source and noise-receiving properties.

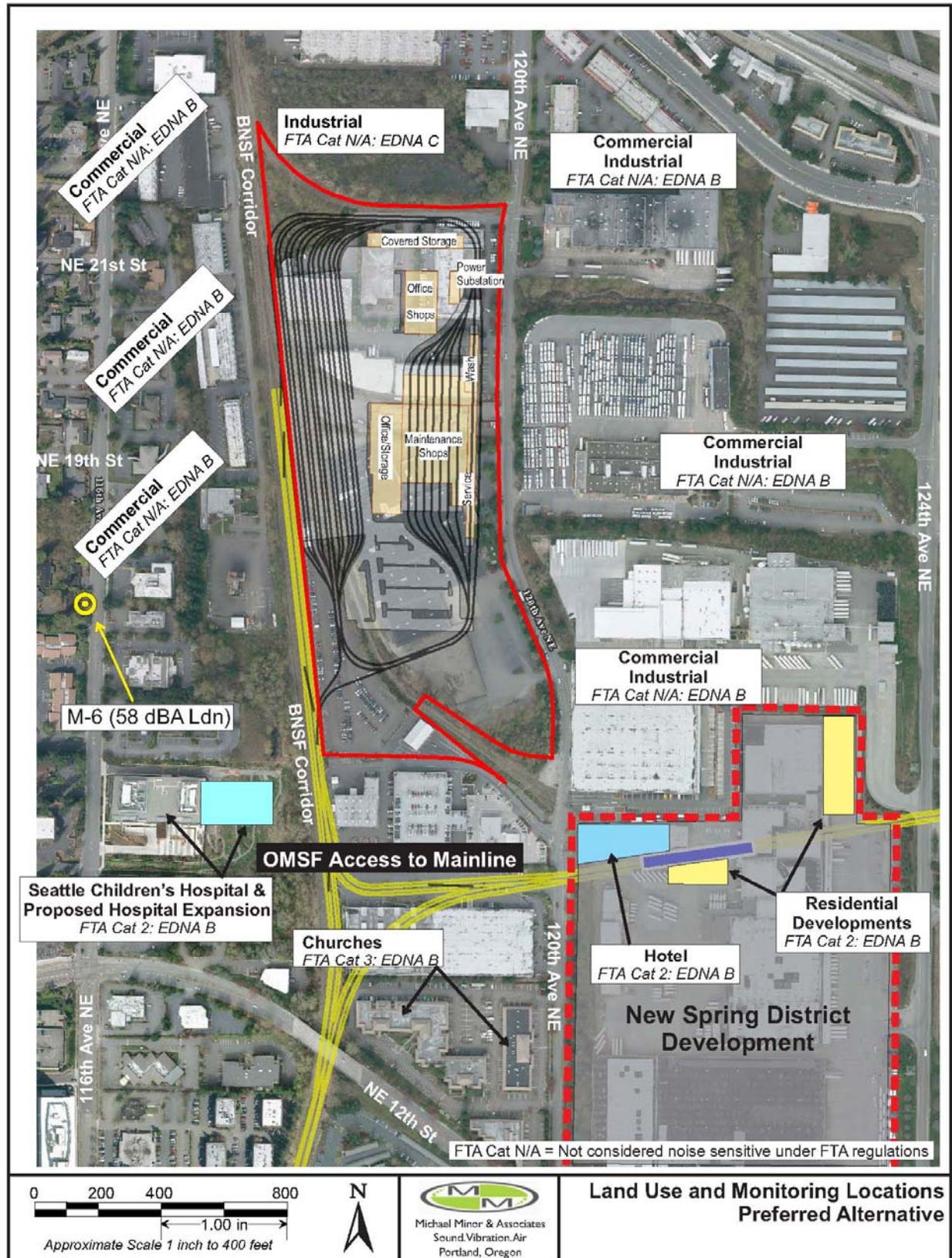
4.1 Preferred Alternative

The Preferred Alternative site is located in a primarily commercial and industrial area, north of NE 12th Street and south of SR 520 along the Eastside Rail Corridor. Under the FTA criteria, the actual land use, not the City zoning designation, is used to determine the noise analysis category. Because of this fact, there are differences in how some properties are analyzed for noise impacts. First, under the FTA criteria, most commercial and industrial land uses are not considered noise sensitive and, therefore, are not analyzed for noise impacts. The nearest noise-sensitive land use under the FTA criteria that is located near the Preferred Alternative site is the Seattle Children's Hospital: Bellevue Clinic and Surgery Center. This facility also contains equipment that is sensitive to vibration. The hospital has a planned expansion to the east of the existing building, which will include new medical facilities and additional parking. The hospital was evaluated as FTA category 2 for noise and FTA category 1 for vibration due to the vibration sensitive equipment at this facility.

Other noise-sensitive land uses near the site under the FTA criteria include the Redeemed Christian Church of God Victory Court and the All Saint's Episcopal Church (both FTA Category 3). Both churches are located in a business park north of NE 12th Street and west of 120th Avenue NE.

The City of Bellevue has approved a Master Development Plan (MDP) for 36 acres in the Bel-Red Subarea to convert the current industrial uses to a transit-oriented urban village, referred to as the Spring District. Because the Spring District MDP is planned and permitted, it is treated as an existing use for this analysis. The Spring District will be a mixed-use development that will contain office space, retail, housing, hotels, parks, and a new road system with the necessary infrastructure. The current plan includes construction of 29 buildings following demolition of the existing industrial structures. The entire redevelopment is planned over a 15-year period with seven construction phases. The proposed redevelopment is located southeast of the Preferred Alternative site. Two Spring District residential structures and a hotel (all FTA Category 2) are planned as part of the redevelopment and shown in Figure 4-1.

Figure 4-1. Preferred Alternative Site—Land Use and Monitoring Locations



Construction of the hotel is planned for 2022 through 2024, Phase 4 of the project. Construction of the residential structures near 120th Avenue NE and 124th Avenue NE are planned for 2024 through 2026 (Phase 5) and 2026 through 2028 (Phase 6). There are no proposed parks or recreational resources in the Spring District. Other noise-sensitive uses in the Spring District development are either commercial or located so far south of the OMSF that there is no potential for a noise impact.

As required by the Bellevue City Code, the zoning designation is used to determine the EDNA classification for the noise analysis. The Preferred Alternative site is located in an area zoned for office and residential mixed use (City Zones BR-OR-2 and BR-R: EDNA Class B). Properties north and east of the site are zoned similarly (City Zones BR-OR-1, BR-OR-2 and BR-R: EDNA Class B and BR-GC: EDNA Class C). West of the site, along 116th Avenue NE, land use includes the Seattle Children's Hospital: Bellevue Clinic and Surgery Center (City Zone MI: EDNA Class B), which has a planned expansion to the east for a new surgical center and parking area, several commercial and office spaces, and several single-family residences (all City Zone BR-MO: EDNA Class B). There are also several converted single-family homes that are now used as offices on 116th Avenue NE near NE 20th Street (all City Zone BR-MO: EDNA Class B). To the south of the site, near NE 12th Street, there is a group of buildings with office and retail uses as well as two churches (City Zone BR-OR-2: EDNA Class B).

Under the City of Bellevue Code, the Spring District, which is located in the Bel-Red Corridor, is designated for mixed-use TOD (City Zones BR-OR, BR-OR-1, BR-OR-2 and BR-CR: EDNA Class B). Existing noise levels near the Preferred Alternative site are dominated by traffic noise from I-405, NE 12th Street, 116th Avenue NE, and other arterial roadways, in addition to commercial and industrial activities. Farther north, the noise levels are dominated by SR 520 and arterial roadways near SR 520, including Northup Way. Noise levels near the remaining single-family residences along 116th Avenue NE were characterized with monitoring site M-6 where noise levels were measured at 58 dBA Leq and 58 dBA Ldn. Current noise levels at Seattle Children's Hospital: Bellevue Clinic and Surgery Center, just south of M-6, and at the Spring District are predicted to be in the mid- to upper 60 dB range because of their proximity to traffic on NE 12th Street and other nearby arterial roads. Noise monitoring at these locations was not performed because it would not produce accurate results because of ongoing construction and industrial activities.

Figure 4-1 provides an overview of the proposed Preferred Alternative site, monitoring locations, noise levels, access tracks, and area land uses. Table 4-1 provides the noise monitoring results for site M-6, which was used to quantify the existing noise levels near sensitive uses for the Preferred Alternative site.

Table 4-1. Preferred Alternative Site Noise Monitoring Results

| Site Number | Address | Land Use Type | Leq ^a | Ldn ^b |
|------------------------------------|----------------------|---|------------------|------------------|
| M-6 | 1815 116th Avenue NE | FTA Cat 2 City Zone BR-MO: EDNA Class B | 58 | 58 |
| ^a Peak-hour Leq in dBA. | | | | |
| ^b 24-hour Ldn in dBA. | | | | |

4.2 BNSF Modified Alternative

The BNSF Modified Alternative site is located in the same general area as the Preferred Alternative site, as described in Section 4.1, *Preferred Alternative*. Permitted developments for the area around the BNSF Modified Alternative site, as well as existing noise levels, are the same as those described above for the Preferred Alternative site.

Figure 4-2 provides an overview of the BNSF Modified Alternative. The figure also shows the noise monitoring locations, noise levels, access tracks to and from the mainline, and area land uses for this build alternative. The Spring District is outlined, and the nearest residential buildings and the hotel in the Spring District are shown for reference.

4.3 SR 520 Alternative

The SR 520 Alternative site is located along the south side of SR 520, between 130th Avenue NE and 136th Place NE and north of NE 20th Street (City Zone BR-GC: EDNA Class C). There are no residences within 700 feet of the site boundaries. The closest residences are located north of SR 520 off NE 24th Street, approximately 725 feet north of the site, and on 127th Avenue NE, also north of SR 520, approximately 825 feet from the site (City Zones R-1, R-2.5 and R-3.5: EDNA Class A). Land use to the west of the site includes commercial and industrial uses, including retail and storage (City Zones BR-R, BR-RC-1 and BR-RC-2: EDNA Class B and BR-GC: EDNA Class C). Along NE 20th Street, south of the site, land use continues to be commercial, light industrial and retail (City Zones BR-RC-1 and BR-RC-2: EDNA Class B and BR-GC: EDNA Class C). East of the site, near 136th Place NE, land use is primarily retail and also includes office spaces and other commercial uses (City Zones BR-CR: EDNA Class B and BR-GC: EDNA Class C). None of the surrounding commercial and industrial land uses are considered noise sensitive under the FTA criteria and, therefore, are not analyzed for noise impacts under those criteria.

Noise levels near the SR 520 Alternative site are dominated by traffic on SR 520, NE 20th Street, and 130th Avenue NE, along with noise from existing commercial and light industrial activities. Noise levels in this area are taken from a short-term measurement at a multifamily residence on NE 21st Place, M-7 approximately 1,000 feet west of the site, where peak-hour noise levels of 72 dBA Leq were due to traffic on SR 520. Noise levels were measured for 24 hours, north of SR 520, at 2311 127th Avenue NE (M-8) during the SR 520 project. The noise levels at this site varied from 71 dBA Leq during peak hours to 60 dBA Leq during nighttime hours, for a 24-hour Ldn of 72 dBA.

Figure 4-2. BNSF Modified Alternative—Land Use and Monitoring Locations

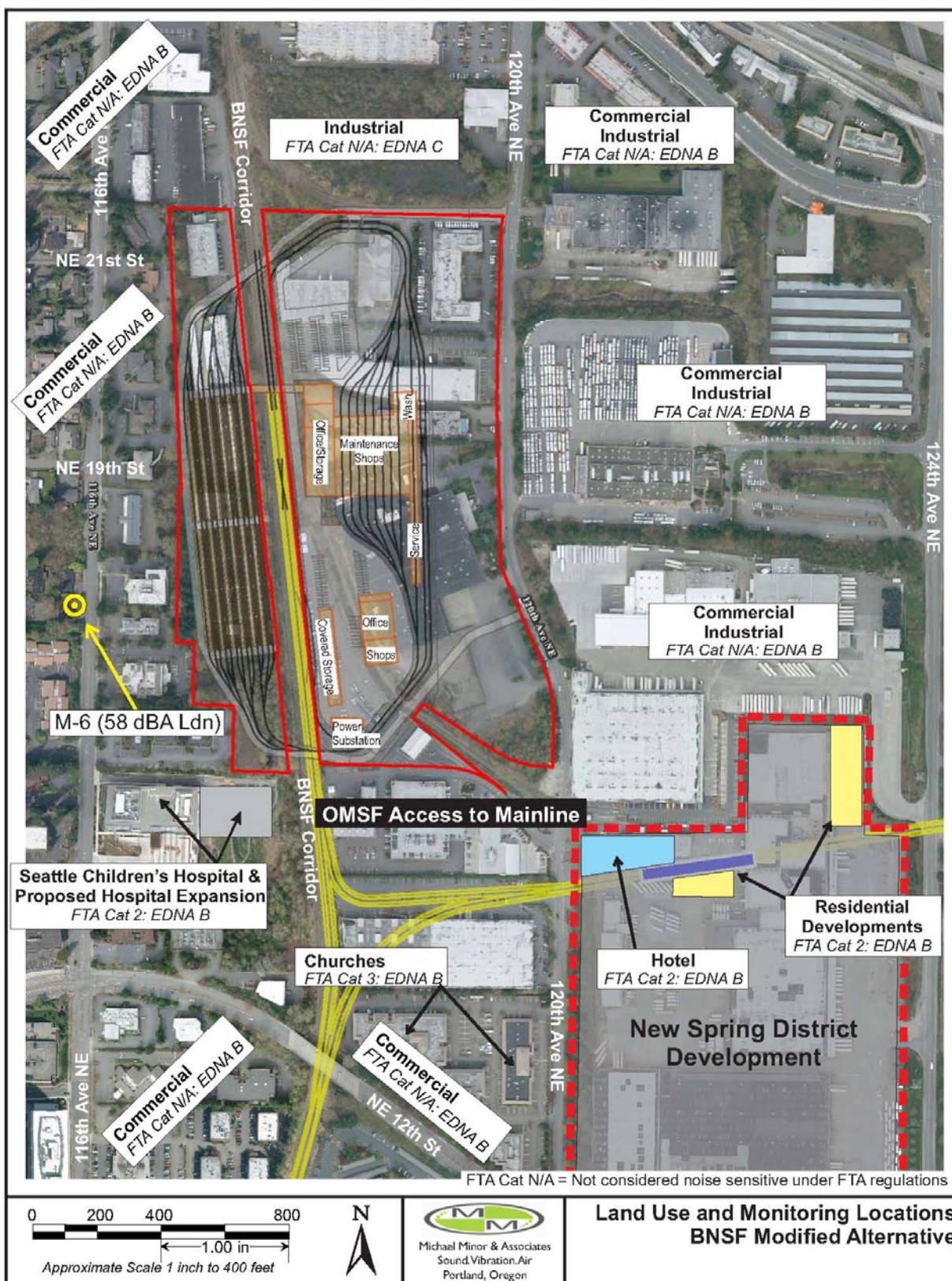


Table 4-2 has the measured noise levels for sites M-7 and M-8 that were used to characterize noise levels at the SR 520 Alternative site. Figure 4-3 provides an overview of the SR 520 Alternative site and also shows the noise monitoring locations and noise levels, access tracks to and from the mainline land uses surrounding this build alternative.

Table 4-2. SR 520 Alternative Noise Monitoring Results

| Site Number | Address | Land Use Type | Leq ^a | Ldn ^b |
|-------------|----------------------|---|------------------|------------------|
| M-7 | 12628 Northup Way | FTA Cat 2 City Zone BR-GC: EDNA Class C | 72 | 70 |
| M-8 | 2311 127th Avenue NE | FTA Cat 2 City Zone R-3.5: EDNA Class A | 71 | 72 |

^a Peak-hour Leq in dBA.
^b 24-hour Ldn in dBA.

4.4 Lynnwood Alternative

The Lynnwood Alternative site has essentially the same layout, with modified connections, as the Lynnwood Link Extension. Land uses near the Lynnwood Alternative site are mostly residential along the west side of 52nd Avenue W (City Zone RS-8: EDNA Class A). East of 52nd Avenue W, adjacent to I-5, there is one single-family residence (20909 52nd Avenue W, City Zone LI: EDNA Class C); land uses then transition to commercial and industrial. Near 50th Avenue W are a warehouse and distribution facility (all City Zone LI: EDNA Class C) as well as the Interurban Trail (City Zone P-1: EDNA Class A). East of 52nd Avenue W are several vacant parcels, state and private office buildings (City Zones LI and BTP: EDNA Class C), and Scriber Creek Park (City Zone P-1: EDNA Class A). Other land uses near the Lynnwood Alternative site include the Park Five Apartments at 20104 48th Avenue W and the 76-unit Cedar Creek Condominiums at 4800–4920 200th Street SW (both City Zone RMM: EDNA Class A).

All of the homes near the Lynnwood Alternative site are FTA Category 2 receivers. None of the surrounding commercial and industrial land uses are considered noise sensitive under the FTA criteria and, therefore, are not analyzed for noise impacts under those criteria. As stated in the FTA regulations, how a park is used and where it is located is considered when determining noise sensitivity. Based on the park location, uses, and existing noise levels, Scriber Creek Park was evaluated under the FTA Category 3 criteria. Scriber Creek Park is open during daylight hours (dusk to dawn).

Existing noise levels in this area were characterized with five monitoring sites. One monitoring site was near I-5, two monitoring sites were along 52nd Avenue W, and two additional monitoring sites were at the Park Five Apartments, near Scriber Creek Park, and at the Cedar Creek Condominiums, also near Scriber Creek Park. Noise levels along 52nd Avenue W are highest near I-5; noise levels near the 52nd Avenue W overpass are approximately 70 dBA Leq during peak hours and have an Ldn of approximately 72 dBA. Farther north, on 52nd Avenue W, away from I-5, noise levels gradually diminish, with peak-hour Leq noise levels ranging from 57 to 64 dBA and Ldn noise levels ranging from 64 to 65 dBA.

Figure 4-3. Land Use and Monitoring Locations—SR 520 Alternative Site



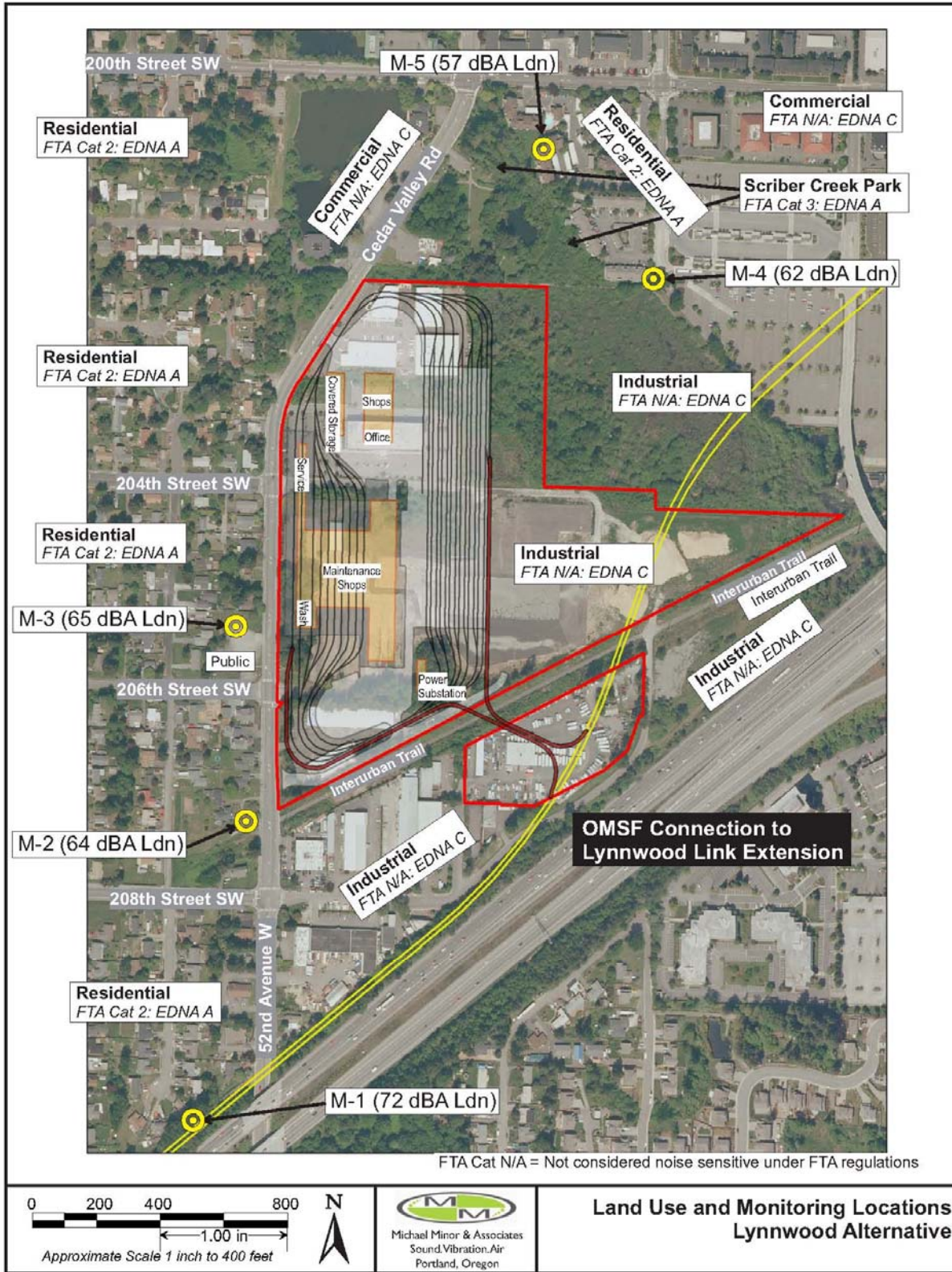
Noise levels near Scriber Creek Park, the Park Five Apartments, and the Cedar Creek Condominiums range from 58 to 62 dBA Leq during peak hours, with Ldn noise levels ranging from 57 to 62 dBA. Major noise sources in this area include traffic on I-5, commercial and industrial activities, and traffic on other arterial roadways.

The monitoring results for sites M-1 through M-5, which were used to characterize the existing noise levels near the Lynnwood Alternative site, are provided in Table 4-3. Figure 4-4 provides an overview of the Lynnwood Alternative site, monitoring locations, noise levels, access tracks, and area land uses.

Table 4-3. Lynnwood Alternative Noise Monitoring Results

| Site Number | Address | Land Use Type | Leq ^a | Ldn ^b |
|-----------------------------------|---|--|------------------|------------------|
| M-1 | 20929 53rd Avenue W | FTA Cat 2 City Zone RS-8: EDNA Class A | 70 | 72 |
| M-2 | 20706 52nd Avenue W | FTA Cat 2 City Zone RS-8: EDNA Class A | 57 | 64 |
| M-3 | 20526 52nd Avenue W (Cedar Valley Grange) | FTA Cat 2,3 City Zone RS-8: EDNA Class A | 64 | 65 |
| M-4 | 20128 48th Avenue W, Bldg. C, Apt. #30 (Park Five Apartments) | FTA Cat 2 City Zone RMM: EDNA Class A | 62 | 62 |
| M-5 | 4900 200th Street SW, Bldg. C (Cedar Creek Condominiums) | FTA Cat 2 City Zone RMM: EDNA Class A | 58 | 57 |
| ^a Peak-hour Leq in dBA | | | | |
| ^b 24-hour Ldn in dBA | | | | |

Figure 4-4. Lynnwood Alternative—Land Use and Monitoring Locations



Chapter 5

Impact Assessment Approach

Noise and vibration from OMSF operations was modeled using the methods described in the FTA Manual (2006). The proposed OMSF would enable Sound Transit to provide service and inspection functions for supporting a fleet of approximately 88 additional LRVs with the assumption that the Forest Street OMF would continue to provide inspection, heavy repair, and overhaul services. The OMSF would be used to store, maintain, and dispatch vehicles for daily service. Activities at the OMSF would include preventative maintenance inspections, light maintenance, emergency maintenance, interior vehicle cleaning, and exterior vehicle washing.

The facility is needed to accommodate additional administrative and operations functions and would be used as a report base for LRV operators. The proposed OMSF would have space for employee parking, operations staff offices, maintenance staff offices, dispatcher workstations, an employee report room, and areas with lockers, showers, and restrooms for both operators and maintenance personnel.

The following sections provide the assumptions that will be used to predict noise and vibration levels associated with the project.

5.1 Noise Assessment Approach

The noise impact assessment includes the analysis of noise from general maintenance operations, cleaning of trains, and the arrival and departure of trains at the OMSF, vehicle movement in the yard and ancillary equipment, including power substation. All four build alternatives would involve construction and operation of storage tracks, offices and an enclosed LRV maintenance building containing service bays for maintaining LRVs. The OMSF would include the following activities and equipment that may produce noise.

- LRV washing area.
- General service, inspection, and repair bays, wheel truing, brake and coupler shop and a welding and general fabrication shop.
- Track, switches, catenary power lines, a traction power substation, and signals to support movement of LRVs to and from the mainline and around the facility through the LRV maintenance building and LRV storage area.
- Lead track to provide access between the OMSF and light rail system mainline.

The analysis uses reference noise levels for operation of a maintenance base taken from the FTA Manual (2006). The operational analysis assumes that the OMSF would operate 24 hours a day. Major operational assumptions include the following.

- The OMSF would store and maintain up to approximately 88 LRVs with storage for an additional 8 spare vehicles. All 88 LRVs would typically depart the OMSF before 7 a.m., with some LRVs returning to the OMSF during midday service and departing the OMSF for PM peak service, returning again as service is reduced during evening and nighttime hours. The remaining LRVs would return to the OMSF at the end of revenue service. Noise levels for trains accessing the

OMSF were projected using measured noise levels from Sound Transit's existing LRV fleet and the calculation methods provided in the FTA Manual (2006).

- The LRV wash area would be enclosed with openings on each end for LRV access. Blowers would be used to strip water off the vehicles; the blowers would be located inside the end of the LRV wash structure. The noise sources associated with the LRV wash and blowers would include a vacuum system and an air compressor. Manufacturers of LRV wash systems were contacted to determine design options that could be used to reduce noise from the blowers. There are typically eight to 10 blowers, each producing 15 horsepower. The systems are used to circulate air and move water off the vehicles. Based on measurements of similar wash facilities, the sound level at a distance of 50 feet is assumed to be 74 dBA, assuming the blowers are located at the end of the wash bay, directly adjacent to the exit, and the door to the wash bays are open. The LRV wash would typically be used for 50 to 60 minutes per day. This is based on the wash cycle for a four-car train taking approximately 10 minutes and approximately four to five four-car trains washed each day (approximately 25% the fleet stored at the OMSF). As a worst case, this analysis assumes the loudest 1-hour of LRV washing operations, and also assumes that the operations would occur during nighttime hours, which is typical, when regulations are the most stringent for residential uses (Class A EDNA).
- Sound Transit would perform limited outdoor testing of train-mounted horns or bells; the testing would occur only during the daytime.
- Although wheel squeal can be an issue because of the low speed limit of no more than 8 miles per hour (mph) for LRVs operating in the OMSF yard, it is not predicted to be an issue of concern. Any wheel squeal on the curves into and out of the storage tracks would be resolved with lubrication or friction modifiers. Wheel squeal was not included in the noise model for the OMSF.
- The slow speed on the storage tracks would also reduce any impact noise associated with crossovers at the OMSF. Only the crossovers that connect the mainline tracks to the access tracks were included in the analysis because the trains on the mainline would be traveling at higher speeds than those on the access tracks.
- The lead track, which would provide access between the OMSF and light rail system mainline, would produce 56 dBA Leq at 50 feet, assuming up to 40 vehicles (10 four-car trains) in the peak hour as a worst-case assumption. Normal operations would typically only require seven to eight trains to use the access track during the peak hour. Because of the special trackwork proposed for the lead tracks and the slow speeds (10 mph), a conservative 5 dBA increase in noise was assumed from the crossover, which is 2 to 3 dB higher than expected.
- There would be limited LRV movement inside the yard. Once LRVs enter a storage yard and are parked, they would usually stay in place until they go back into revenue service. Movements within the yard would include shuttling LRVs to the shop and through the LRV wash and cleaning station. Assuming the worst case by using the maximum capacity of 96 LRVs moving around the yard at 8 mph in a single hour, LRV movement around the facility, and through the LRV maintenance building and LRV storage area, would produce an hourly Leq of 60 dBA at 50 feet. This level of activity, although not feasible, was used to ensure a worst-case noise analysis.
- Noise from general maintenance activities inside the shop building would include use of hand tools, continuous operation of compressors and other mechanical equipment, and intermittent operation of equipment such as overhead cranes, vehicle lifts, and the wheel trues. The

equipment would all be located inside the maintenance shop. The predictions of the noise that would be emitted from the shop are based on measurements at the existing Sound Transit Operations and Maintenance Base in Seattle and measurements at the Los Angeles Metro Green Line Yard in California. For this analysis, it was assumed that bay doors would be left open for ventilation, making this a worst-case analysis and the typical sound level would be 69 dBA at 50 feet outside the work bays with the bay doors open. With the doors closed, the noise from general maintenance activities would not affect the overall noise from the facility.

- Some equipment in the shop, such as the vehicle lifts and overhead cranes, may be equipped with alarms to alert workers before they are used. In the design of the shop facility, the use of these alarms would be minimized and any alarms used would be designed to provide appropriate warning for shop personnel and to be inaudible beyond the maintenance yard property line.
- The noise from the traction power substations in the maintenance yard would be a maximum of 49 dBA at 50 feet but would not be considered a notable noise source at the OMSF. This is based on measurements of Metro Gold Line in South Pasadena.
- Activities at the cleaning station would include vacuuming and hand cleaning of the vehicle interior. This is an insignificant noise source because the noise would occur inside the LRVs. A cleaning station would be required at the BNSF Storage Tracks along the BNSF corridor under the Lynnwood Alternative.

The worst-case nighttime hour assumes that 40 LRVs (10 four-car trains) would depart from the OMSF site, 96 LRVs would move around inside the OMSF, the LRV wash system would be in operation for the full hour, and maximum noise from the maintenance bays would all occur simultaneously. The daytime hour assumes the same noise sources but without the LRV wash system, which is typically used only at night.

Distances from each of the noise sources to the nearby structures or property lines were measured using AutoCAD design drawings with high-resolution aerial photos. The reference noise levels were then distance corrected, using standard acoustical formulas, and summed to provide the combined noise levels from OMSF operations at each location.

Using the above assumptions, the 24-hour Ldn, peak nighttime hourly Leq, and typical daytime hour Leq were calculated and used to predict potential noise impacts. The 24-hour Ldn was compared to the appropriate FTA noise criteria from Section 3.1, *FTA Noise Criteria*. The peak-hour Leq was used to assess noise impacts under the applicable local noise control ordinance from Section 3.4, *Local Noise Control Ordinances*.

5.2 Light Rail Vibration Assessment Approach

Light rail vibration was predicted using information from the vibration sections of the *East Link Project Final EIS* (Sound Transit 2012) and the *Lynnwood Link Extension Draft Vibration Technical Report* (Sound Transit 2013). Based on these documents and the track-type adjustments for ballast and tie, direct fixation, and aerial guideway alignments, vibration impacts could occur only at FTA Category 2 structures located within 100 feet of the Preferred Alternative site. In addition, vibration impacts are predicted to occur only within 70 feet of the Lynnwood Alternative site and within 100 feet of the Preferred Alternative, BNSF Modified Alternative, and SR 520 Alternative sites as well as

the BNSF Storage Tracks. The larger impact distance for these build alternatives would be due to the different vibration propagation characteristics of the soils at the different sites.

The distances from nearby structures were measured using AutoCAD design drawings with high resolution aerial photos to determine the number of type of uses that would be within the distances for potential vibration impacts. Adjustments for track type and any mitigation proposed as part of the East Link Project and Lynnwood Link Extension were included in the model. Based on the results of the analysis, the corridor was examined for potential vibration impacts.

The only Category 1 site identified in the vicinity of the OMSF is the Seattle Children's Hospital: Bellevue Clinic and Surgery Center. The hospital contains equipment that is sensitive to vibration. It also has a planned expansion to the east of the existing building, which will include new medical facilities and additional parking. Vibration levels were predicted using the East Link Final EIS and data from propagation measurements taken near the hospital during the East Link Project. Track type and special trackwork were included in this analysis. Because of the slower speeds and special trackwork along the trail tracks, a conservative 5 VdB increase in vibration was assumed from the crossover, which is higher than would be expected under these operations.

This section provides the results of the noise and vibration impact analysis. It also includes a construction noise and vibration analysis as well as a review of potential indirect noise impacts. The impact analysis of the build alternatives used worst-case activities, assuming 40 LRVs would depart from the OMSF site, 96 LRVs would move around inside the OMSF, the LRV wash system would be in operation, and maximum noise from the maintenance bays would occur simultaneously in a single hour. The daytime calculations assumed the same noise sources but without the LRV wash system, which is typically used only at night. Because it is highly unlikely that this situation would ever occur, the noise levels projected are worst case and higher than typical operational noise levels measured at similar facilities. Cumulative noise and vibration impacts are discussed in Chapter 8, *Cumulative Analysis*.

6.1 No Build Alternative

Under the No Build Alternative, noise and vibration levels would continue to be dominated by traffic on nearby major highways, commercial and industrial activities and local traffic on nearby arterial roadways.

With operation of the Lynnwood Link Extension, noise levels at the southern end of 52nd Avenue W are not expected to increase because light rail noise walls are included along that part of the corridor. Other noise sources in the area, including I-5, 200th Street SW, 52nd Avenue W, and other arterial roadways, along with nearby commercial and industrial activities, would continue to dominate the noise levels in most areas near the Lynnwood Alternative site.

With operation of East Link, a new noise source would be added to the general area proposed for the Preferred Alternative, BNSF Modified Alternative, and SR 520 Alternative sites. However, the build alternative sites are 400 to 500 feet from the East Link mainline; therefore, operation of East Link is not predicted to affect noise levels near the Preferred Alternative, BNSF Modified Alternative, or SR 520 Alternative sites. Other noise sources in the area, including I-405, SR 520, NE 12th Street, 116th and 120th Avenues NE, Northup Way, and other arterial roadways, along with nearby commercial and industrial activities, would continue to dominate the noise levels in most areas near the sites.

6.2 Preferred Alternative

A noise analysis for the Preferred Alternative site was performed using both the FTA criteria and the local noise control ordinance from the City of Bellevue. The City of Bellevue ordinance classifies EDNAs according to the land use districts listed in BCC 9.18.025. One noise impact, but no vibration impact, is predicted for the Preferred Alternative site. Details regarding the analysis are provided below. Table 6-1 provides the results of the noise analysis, and Figure 6-1 shows the location of the impact.

Table 6-1. Preferred Alternative Noise Analysis Results

| Address ^a | Bellevue Analysis Peak Hour Leq ^b (dBA) | | | FTA Analysis (24-hour Ldn or peak-hour Leq dBA) | | | Impact Type and Criteria Exceeded ^f |
|--|--|-----------|----------------------|---|----------------------|---------------------------|---|
| | Day | Night | Criteria Day (Night) | Existing ^c | Project ^d | FTA Criteria ^e | |
| Children's Hospital 1500 116th Ave NE | 48 | 49 | 60 (60) | 65 | 46 | 61 | None |
| Medical Offices 1600 116th Ave NE | 48 | 50 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Public Safety Training Center 1838 116th Ave NE | 54 | 55 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Construction Industry Council Offices 1930 116th Ave NE | 56 | 57 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Redeemed Christian Church 1277 120th Avenue E | 41 | 44 | 60 (60) | 65 | 44 | 66 | None |
| All Saint's Episcopal Church 1307 120th Ave NE | 41 | 44 | | 65 | 44 | 66 | None |
| King County Transit Bus Maintenance Base (industrial use east of OMSF) – North | 50 | 65 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | One commercial facility with nighttime Bellevue code impact from LRV wash |
| King County Transit Bus Maintenance Base (industrial use east of OMSF) – South | 54 | 57 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Safeway Distribution Center (industrial use east of OMSF) | 48 | 51 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Spring District Hotel Near Station | 46 | 48 | 60 (60) | 65 | 45 | 61 | None |
| Spring District Multi-Family Structure 1 | 41 | 45 | 60 (60) | 65 | 42 | 61 | None |
| Spring District Multi-Family Structure 2 | 40 | 45 | 60 (60) | 65 | 42 | 61 | None |

Note: Values in bold text meet or exceed the applicable noise impact criteria.

^a Address of representative parcel used in modeling.

^b Bellevue noise criteria for EDNA Class B next to another EDNA Class B property is 60 dBA Leq during peak hour. The nighttime criteria is the same as daytime for EDNA Class B. Any location where maximum permissible sound level exceeds 60 dBA Leq is in bold.

^c Existing Ldn (Category 2) or peak-hour Leq (Category 3).

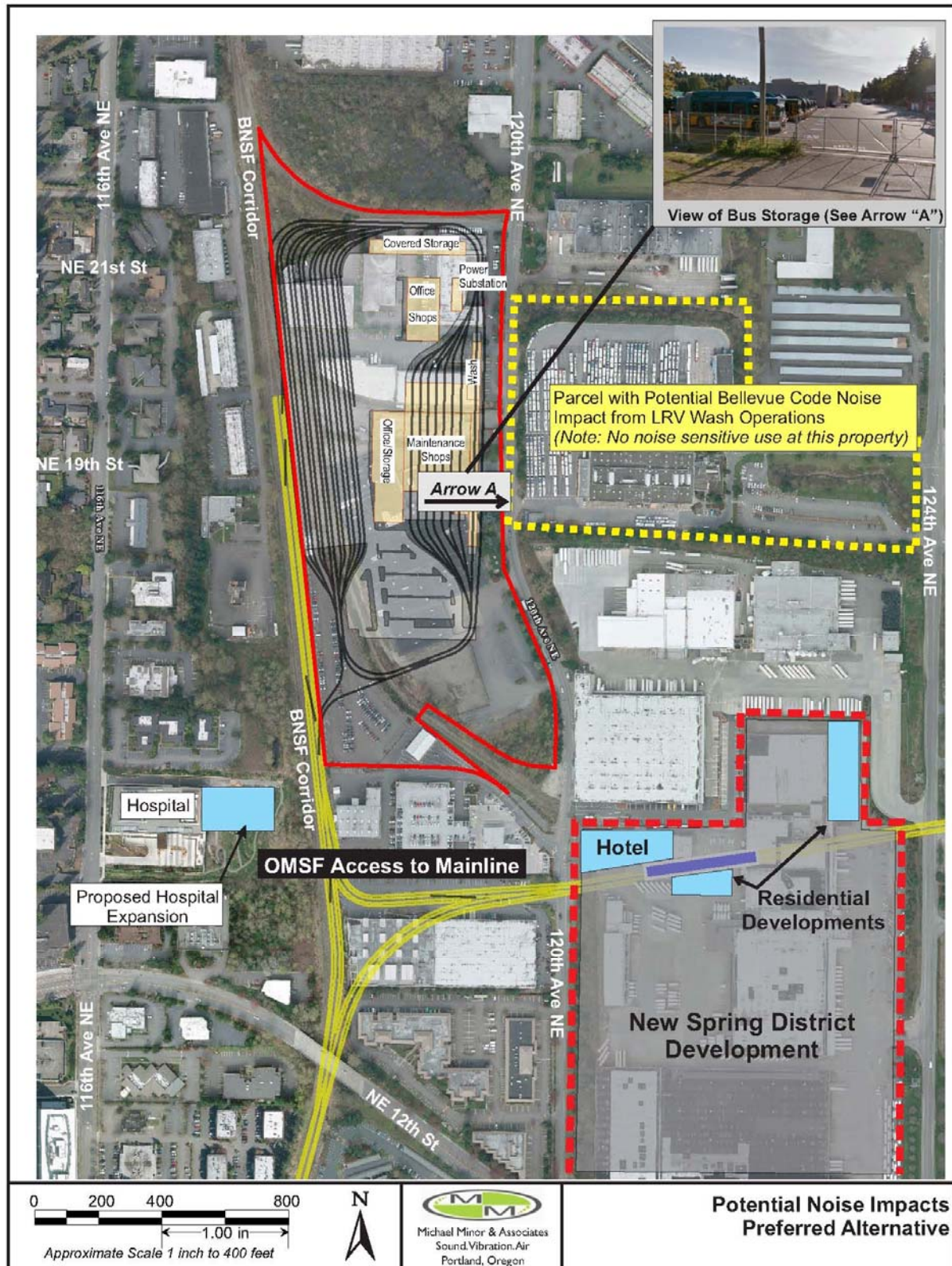
^d Noise levels from OMSF operations (Ldn for Category 2 or peak-hour Leq for Category 3).

^e FTA moderate impact criteria for 24-hour Ldn for Category 2 land uses.

^f Number and type of noise impacts – all impacts occur at night when the LRV wash is operating and only under the City of Bellevue noise control ordinance.

N/A = not applicable; dBA = decibels with A-Weighting; FTA = Federal Transit Administration

Figure 6-1. Preferred Alternative—Impacts



6.2.1 Noise Impacts

Under the Preferred Alternative, the only noise impact would occur at the existing Metro bus storage and maintenance base. This impact would occur only under the City of Bellevue Noise Control Ordinance and in the area used for bus parking and storage. This impact occurs for two reasons. First, the OMSF is considered, by the City of Bellevue, an EDNA B, even though it would typically be designated an EDNA C. Furthermore, the bus storage zoning designation is BR-OR (EDNA B), but the current use is industrial. Thus, it would typically be classified EDNA C. If either of these facilities were designated EDNA C, there would be no noise impact. Noise levels at the office building on the site are within the City of Bellevue Noise Control Ordinance criteria. There are no FTA criteria applicable to the Metro bus storage and maintenance base and, therefore, no impacts under the FTA criteria. No properties, other than the Metro bus storage and maintenance base, would have noise impacts under either the FTA regulations or City of Bellevue Noise Control Ordinance.

The Seattle Children's Hospital: Bellevue Clinic and Surgery Center (FTA Category 2, EDNA Class B), which has planned improvements to expand to the east toward the Preferred Alternative site, is the nearest noise-sensitive use to the Preferred Alternative site. Using conservative measurements and the most current design drawings, the new building would be approximately 300 feet southwest of the Preferred Alternative site and approximately 175 feet west of the access tracks. The Seattle Children's Hospital: Bellevue Clinic and Surgery Center is also more than 1,400 feet from the LRV wash system, the loudest noise source at the site, which is well shielded from the hospital by the maintenance building. The maintenance building, also a noise source, is more than 1,100 feet from the Seattle Children's Hospital: Bellevue Clinic and Surgery Center.

The Seattle Children's Hospital: Bellevue Clinic and Surgery Center was evaluated using FTA Category 2 and EDNA Class B. The analysis concluded that there would be no noise impacts under either the FTA or the City of Bellevue Noise Control Ordinance criteria at the Seattle Children's Hospital: Bellevue Clinic and Surgery Center.

Residential buildings in the Spring District, which are considered EDNA Class B under the Bellevue Code, would be located 525 to 850 feet from the Preferred Alternative site, and the nearest hotel would be approximately 230 feet from the site. These structures are more than 1,500 feet from the LRV wash system, which is the loudest noise source at the OMSF. Because of the large distances and structural shielding, no noise impacts would occur at any structures in this new development. The only other residences near the site are single-family residences along the west side of 116th Avenue NE (FTA Category 2 and EDNA Class B), which would be more than 650 feet away and well shielded from the OMSF by existing structures. The two nearby churches would also be more than 450 feet away from the access tracks and more than 1,000 feet from all other OMSF noise sources (2,000 feet from the LRV wash). Table 6-1 provides the results of the noise analysis.

6.2.2 Vibration Impacts

The distance from the OMSF tracks to the Seattle Children's Hospital: Bellevue Clinic and Surgery Center, the closest vibration-sensitive use, is approximately 250 feet, and the distance from the access tracks to the new hospital building is approximately 175 feet. Because of the sensitive equipment in the hospital, it was evaluated as an FTA category 1 land use, with a maximum 1/3 octave band criteria of 60 VdB. A light rail vehicle traveling at 10 to 15 mph with a standard crossover would produce a composite vibration level of 53 VdB and a maximum 1/3 octave band level of 46 VdB at 31.5 Hz at the hospital. Although there would be a crossover along this alignment,

the LRVs' slow speed and distance from the hospital are enough to reduce the vibration levels below the FTA criteria. Therefore, no vibration impacts are projected.

6.3 BNSF Modified Alternative

The noise analysis for the BNSF Modified Alternative site used both the FTA criteria and the BCC, which classifies EDNAs according to the land use districts listed in the code (BCC 9.18.025). No noise or vibration impacts are predicted under the BNSF Modified Alternative. Details regarding the analysis are provided below.

6.3.1 Noise Impacts

No noise impacts would occur under the BNSF Modified Alternative. The majority of land use surrounding the BNSF Modified Alternative site is classified EDNA B (commercial) and EDNA C (industrial). The Seattle Children's Hospital: Bellevue Clinic and Surgery Center (FTA Category 2 and EDNA Class B) is approximately 180 feet southwest of the site and approximately 200 feet west of the access tracks. Residences near the site are along the west side of 116th Avenue NE (FTA Category 2 and EDNA Class B) and more than 400 feet away; they would be well shielded from the OMSF by existing structures. The two nearby churches would also be more than 400 feet away from the access tracks. Residential buildings at the proposed Spring District (FTA Category 2 and EDNA Class B) would be 875 to 1,100 feet from the BNSF Modified Alternative site, with the hotel 500 feet from the BNSF Modified Alternative site, which is outside the potential distance for noise impacts. No noise impacts were identified at any of these structures. Noise levels were projected for the Seattle Children's Hospital: Bellevue Clinic and Surgery Center (FTA Category 2 and EDNA Class B) and several commercial and industrial sites near the BNSF Modified Alternative site. No noise impacts were identified under the FTA or BCC. The results are provided in Table 6-2.

Table 6-2. BNSF Modified Alternative Noise Analysis Results

| Address ^a | Bellevue Analysis Peak Hour Leq ^b (dBA) | | | FTA Analysis (24-hour Ldn or peak-hour Leq dBA) | | | Impact Type and Criteria Exceeded ^f |
|--|--|-------|----------------------|---|----------------------|---------------------------|--|
| | Day | Night | Criteria Day (Night) | Existing ^c | Project ^d | FTA Criteria ^e | |
| Children's Hospital 1500 116th Ave NE | 51 | 51 | 60 (60) | 65 | 48 | 61 | None |
| Medical Offices 1800 116th Ave NE | 49 | 51 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Medical Offices 1900 116th Ave NE | 5 | 53 | 60 (60) | N/A ^g | N/A | N/A ^g | None |
| Medical Offices 1940 116th Ave NE | 49 | 52 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| The Redeemed Christian Church of God Victory Court 1277 12th Ave NE | 42 | 45 | 60 (60) | 65 | 45 | 66 | None |
| All Saint's Episcopal Church 1307 120th Ave NE | 42 | 45 | 60 (60) | 65 | 45 | 66 | None |

| Address ^a | Bellevue Analysis Peak Hour Leq ^b (dBA) | | FTA Analysis (24-hour Ldn or peak-hour Leq dBA) | | | Impact Type and Criteria Exceeded ^f | |
|--|--|-------|---|-----------------------|----------------------|--|---------------------------|
| | Day | Night | Criteria Day (Night) | Existing ^c | Project ^d | | FTA Criteria ^e |
| King County Transit Bus Maintenance Base (industrial use east of OMSF) – North | 50 | 60 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| King County Transit Bus Maintenance Base (industrial use east of OMSF) – South | 54 | 57 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Safeway Distribution Center (industrial use east of OMSF) | 48 | 51 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Spring District Hotel Near Station | 45 | 48 | 60 (60) | 65 | 45 | 61 | None |
| Spring District Multi-Family Structure 1 | 41 | 45 | 60 (60) | 65 | 42 | 61 | None |
| Spring District Multi-Family Structure 2 | 40 | 45 | 60 (60) | 65 | 42 | 61 | None |

Note: Values in bold text meet or exceed the project noise impact criteria.

^a Address of representative parcel used in modeling.

^b City of Bellevue Noise Control Ordinance for EDNA Class B next to another EDNA Class B property is 60 dBA Leq. Details are provided in Section 3.4.1, *City of Bellevue Noise Control Ordinance*.

^c Existing Ldn for the Seattle Children's Hospital: Bellevue Clinic and Surgery Center, the hotel, and the multi-family structures (FTA Category 2) and Leq for churches (FTA Category 3).

^d The 24-hour Ldn or Leq noise from OMSF operations. The Ldn is given for the Seattle Children's Hospital: Bellevue Clinic and Surgery Center, the hotel, and the multi-family structures and the Leq for churches

^e FTA moderate impact criteria based on existing noise level and the applicable land use criteria.

^f Number and type of noise impacts—all impacts occur only at night when the LRV wash is operating.

^g The use is commercial or industrial; there is no FTA noise impact criterion for commercial or industrial uses.

6.3.2 Vibration Impacts

Under the BNSF Modified Alternative, the distance from the OMSF tracks to the Seattle Children's Hospital: Bellevue Clinic and Surgery Center, the closest vibration-sensitive use, is approximately 180 feet, and the distance from the access tracks to the new hospital building is approximately 200 feet. Vibration levels from rail operations at the Seattle Children's Hospital: Bellevue Clinic and Surgery Center would be the same, or slightly less, than predicted under the Preferred Alternative (Section 6.2.2, *Vibration Impacts*). Therefore, no vibration impacts are projected.

The SR 520 Alternative site is an EDNA Class C property. Properties adjacent to the site are classified as EDNA Class B and Class C. EDNA Class A (public park) properties north of the site are more than 700 feet from the site, outside the area of potential noise impacts. Therefore, for the analysis under the City of Bellevue Noise Control Ordinance, noise levels were evaluated for the nearest EDNA Class B and Class C properties north, south, east and west of the SR 520 Alternative site. Noise levels from the LRV wash system and general OMSF operations are below the City of Bellevue Noise Control

Ordinance. Based on the current design drawings, no noise impacts were identified at any nearby structures under the FTA criteria or BCC. Table 6-3 provides the results of the noise analysis.

Table 6-3. SR 520 Alternative Noise Analysis Results

| Address ^a | Bellevue Analysis Peak Hour Leq ^b (dBA) | | | FTA Analysis (24-hour Ldn or peak-hour Leq dBA) | | | Impact Type and Criteria Exceeded ^f |
|----------------------------------|--|-------|----------------------|---|----------------------|---------------------------|--|
| | Day | Night | Criteria Day (Night) | Existing ^c | Project ^d | FTA Criteria ^e | |
| Commercial Use North of the OMSF | 47 | 52 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Commercial Use East of the OMSF | 49 | 52 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Commercial Use West of the OMSF | 51 | 55 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |
| Commercial Use South of the OMSF | 57 | 62 | 60 (60) | N/A ^g | N/A ^g | N/A ^g | None |

Note: Values in bold text meet or exceed the project noise impact criteria.

^a Address of representative parcel used in modeling.

^b City of Bellevue Noise Control Ordinance for EDNA Class C next to an EDNA Class B property is 65 dBA Leq and next to another EDNA Class C property is 70 dBA Leq. Details are provided in Section 3.4.1, *City of Bellevue Noise Control Ordinance*.

^c Existing Ldn.

^d The 24-hour Ldn or Leq noise from OMSF operations.

^e FTA moderate impact criteria based on existing noise level and the applicable land use criteria.

^f Number and type of noise impacts

^g The use is commercial or industrial; there is no FTA noise impact criterion for commercial or industrial uses.

6.3.3 Vibration Impacts

The distance from the SR 520 Alternative site to the closest commercial use is approximately 100 feet, which is beyond the for potential vibration impact at vibration-sensitive daytime uses. This is based on the measured vibration data from the FTA Manual (2006) that shows that vibration levels will be below 70 VdB at 100 feet from a typical LRV traveling at 50 mph. Therefore no vibration impacts are projected.

6.4 Lynnwood Alternative

The Lynnwood Alternative would connect to the Lynnwood Link Extension. Noise analysis for the site was evaluated using both the FTA criteria and the local noise control ordinance from the City of Lynnwood. The City of Lynnwood ordinance classifies EDNAs according to zoning designations (LMC 10.12.400). The Lynnwood Alternative site is an EDNA Class C property. Properties adjacent to the Lynnwood Alternative site are classified as EDNA Class A, Class B, and Class C. There are 19 noise impacts, but no vibration impacts, predicted for the Lynnwood Alternative site. Details on the analysis are provided below. Table 6-4 provides the results of the noise analysis; Figure 6-2 shows the location of the impacts.

Table 6-4. Lynnwood Alternative Noise Analysis Results

| Address ^a | Lynnwood Analysis Peak Hour Leq ^b (dBA) | | | FTA Analysis (dBA) | | | Number and Type of Impacts ^f |
|--|---|-------|----------------------------|-----------------------|----------------------|------------------------------|---|
| | Day | Night | Criteria Day (Night) | Existing ^c | Project ^d | FTA Criteria ^e | |
| 5211 208th St SW | 46 | 50 | 60 (50) | 64 | 47 | 61 | None |
| 20706 52nd Ave W | 50 | 53 | 60 (50) | 64 | 50 | 61 | Lynnwood nighttime code impact at single- family home |
| 20628 52nd Ave W | 51 | 54 | 60 (50) | 64 | 51 | 61 | Lynnwood nighttime code impact at single- family home |
| 20624 52nd Ave W | 51 | 55 | 60 (50) | 64 | 51 | 61 | Lynnwood nighttime code impact at single- family home |
| 20618 52nd Ave W | 51 | 55 | 60 (50) | 64 | 52 | 61 | Lynnwood nighttime code impact at single- family home |
| 5210 206th St SW | 51 | 57 | 60 (50) | 64 | 54 | 61 | Lynnwood nighttime code impact at single- family home |
| 20526 52nd Ave W (Cedar Valley Grange) | 54 | 61 | 60 (50) | 64 | 58 | 61 | Lynnwood nighttime code impact at public space analyzed as a single-family home |
| 20504 52nd Ave W | 54 | 59 | 60 (50) | 64 | 56 | 61 | Lynnwood nighttime code impact at single- family home |
| 20430 52nd Ave W | 54 | 57 | 60 (50) | 64 | 54 | 61 | Lynnwood nighttime code impact at single- family home |
| 20416 52nd Ave W | 52 | 54 | 60 (50) | 64 | 52 | 61 | Lynnwood nighttime code impact at single- family home |
| 20410 52nd Ave W | 54 | 55 | 60 (50) | 64 | 53 | 61 | Lynnwood nighttime code impact at single- family home |
| 20406 52nd Ave W | 54 | 55 | 60 (50) | 64 | 53 | 61 | Lynnwood nighttime code impact at single- family home |

| Address ^a | Lynnwood Analysis Peak Hour Leq ^b (dBA) | | | FTA Analysis (dBA) | | | Number and Type of Impacts ^f |
|-----------------------|---|-----------|----------------------------|-----------------------|----------------------|------------------------------|--|
| | Day | Night | Criteria Day (Night) | Existing ^c | Project ^d | FTA Criteria ^e | |
| 5207 204th St | 54 | 55 | 60 (50) | 64 | 52 | 61 | Lynnwood nighttime code impact at single- family home |
| 20316 52nd Ave W | 54 | 55 | 60 (50) | 64 | 52 | 61 | Lynnwood nighttime code impact at single- family home |
| 20306 52nd Ave W | 53 | 53 | 60 (50) | 64 | 50 | 61 | Lynnwood nighttime code impact at single- family home |
| 20302 52nd Ave W | 51 | 52 | 60 (50) | 64 | 49 | 61 | Lynnwood nighttime code impact at single- family home |
| 20220 52nd Ave W | 49 | 49 | 60 (50) | 64 | 47 | 61 | None |
| 20505 53rd Ave W | 46 | 49 | 60 (50) | 61 | 46 | 59 | None |
| 20511 53rd Ave W | 50 | 54 | 60 (50) | 63 | 51 | 60 | Lynnwood nighttime code impact at single- family home |
| 20517 53rd Ave W | 50 | 57 | 60 (50) | 63 | 53 | 60 | Lynnwood nighttime code impact at single- family home |
| 20523 53rd Ave W | 43 | 51 | 60 (50) | 61 | 47 | 59 | Lynnwood nighttime code impact at single- family home |
| 20601 53rd Ave W | 45 | 52 | 60 (50) | 61 | 48 | 59 | Lynnwood nighttime code impact at single- family home |
| 20609 53rd Ave W | 44 | 49 | 60 (50) | 61 | 46 | 59 | None |
| Scriber Creek Park | 47 | 47 | 60 (50) | 62 | 44 | 64 | None |

| Address ^a | Lynnwood Analysis Peak Hour Leq ^b (dBA) | | | FTA Analysis (dBA) | | | Number and Type of Impacts ^f |
|--|---|-------|----------------|-----------------------|----------------------|------------------------------|--|
| | Criteria | | | Existing ^c | Project ^d | FTA Criteria ^e | |
| | Day | Night | Day (Night) | | | | |
| Note: Values in bold text meet or exceed the project noise impact criteria. | | | | | | | |
| ^a Address of representative parcel used in modeling. | | | | | | | |
| ^b City of Lynnwood Noise Control Ordinance for EDNA Class C next to an EDNA Class A property is 60 dBA Leq and 50 dBA Leq at night. Details are provided in Section 3.4.2, <i>City of Lynnwood Noise Control Ordinance</i> . Scriber Creek Park nighttime noise levels provided for comparison purposes; the park is not open at night. | | | | | | | |
| ^c Existing Ldn. | | | | | | | |
| ^d The 24-hour Ldn from OMSF operations | | | | | | | |
| ^e FTA moderate impact criteria for 24-hour Ldn for Category 2 land uses. | | | | | | | |
| ^f Number and type of noise impacts—all impacts occur at night when the LRV wash is operating and only under the City of Lynnwood Noise Control Ordinance. | | | | | | | |

Figure 6-2. Lynnwood Alternative—Impacts



6.4.1 Noise Impacts

For the Lynnwood Alternative, there would be no noise impacts under the FTA criteria and 19 impacts under the City of Lynnwood Noise Control Ordinance. Eighteen noise impacts would occur at single-family residences along 52nd Avenue W that are located near the LRV wash system, with one additional noise impact at the Cedar Valley Grange, which is a community center with primarily daytime use. However, because the Cedar Valley Grange is located in a residential zone, in accordance with the City of Lynnwood Noise Control Ordinance, this property was evaluated as a residence. This facility is not predicted to have noise impacts during normal daytime operational hours, only under nighttime hours when the LRV wash is in operation.

Fifteen of the noise impacts would be due mainly to LRV wash operations, which occur at night. To the north of the wash facility, structural shielding would reduce noise from the LRV wash, and the noise impacts north of 204th Street would be due to other activities, such as maintenance operations and train movements on tracks located on the OMSF grounds.

As defined in Chapter 5, *Impact Assessment Approach*, this analysis assumes that 40 LRVs (10 four-car trains) would depart from the OMSF site, 96 LRVs would move around inside the OMSF site, the LRV wash system would be in operation for the full hour, and the worst-case noise from the maintenance bays would all occur simultaneously. Although this is unlikely to ever occur, this worst-case analysis was performed using these assumptions and resulted in the 19 noise impacts. Scriber Creek Park was also analyzed for noise impacts during the park's operational hours, and no noise impacts were predicted. Table 6-5 provides the results of the noise analysis, and Figure 6-2 shows the location of the impacts.

6.4.2 Vibration Impacts

The distance from the OMSF tracks to the nearest residences would be more than 130 feet; therefore, no vibration impacts are projected.

6.4.3 BNSF Storage Tracks

Under the Lynnwood Alternative, the BNSF Storage Tracks would be installed and maintained along the BNSF right-of-way in Bellevue. The tracks would be used to store trains overnight in preparation for the morning commute. LRVs on these storage tracks would be restricted to the speed for auxiliary tracks (10 mph). The analysis assumes that up to 40 LRVs (10 four-car trains) could be stored and moved during nighttime hours. This is more than the 32 LRVs needed for light rail operations; therefore, this is a worst-case analysis. In addition, the LRV operator would be required to sound the low bell during initial movement back to service. The combination of noise from the slow-moving LRVs and bells were not predicted to result in any noise or vibration impacts because of the distance between the receivers and the storage tracks (more than 175 feet).

6.5 Construction Impacts

This analysis considers the temporary noise effects that construction would cause in the build alternative sites. These effects would end when project construction is completed. Project construction related to noise and vibration are considered in this section.

6.5.1 Construction Noise

Equipment required to complete the proposed project includes normal construction equipment that is used for many roadway and structural construction projects. Table 6-5 provides a typical list of the types of equipment used for this type of project, the activities they would be used for, and the corresponding maximum noise level as measured at 50 feet, under normal use.

Table 6-5. Construction Equipment List, Use, and Maximum Noise Levels

| Equipment | Typical Expected Project Use^a | Typical Noise Level at 50 feet in dBA^b |
|---------------------|--|--|
| Air Compressors | Used for pneumatic tools and general maintenance | 81 |
| Backhoe | General construction and yard work | 80 |
| Concrete Pump | Pumping concrete | 82 |
| Concrete Saws | Concrete removal, utilities access | 75–80 |
| Crane | Materials handling, removal and replacement, | 83–88 |
| Excavator | General construction and materials handling | 82–88 |
| Fork Lifts | Staging area work and hauling materials | 72 |
| Generators | Lighting and staging area | 78–81 |
| Pavement Grinder | Remove top coat of pavement for resurfacing | 88 |
| Haul Trucks | Materials handling, general hauling | 86–88 |
| Jack Hammers | Pavement removal | 88 |
| Loader | General construction and materials handling | 85 |
| Paver | Apply pavement overlay | 89 |
| Power Plants | General construction use, nighttime work | 72 |
| Pumps | General construction use, water removal | 76 |
| Pneumatic Tools | Miscellaneous construction work | 85 |
| Service Trucks | Repair and maintenance of equipment | 72 |
| Tractor Trailers | Material removal and delivery | 82–86 |
| Utility Trucks | General project work | 72 |
| Vibratory equipment | Soil compacting | 82–88 |
| Welders | General project work, track welds | 76 |

^a Typical project uses.

^b Typical maximum noise level under normal operation as measured at 50 feet from the noise source, FTA 2006.

Several phases would be required to complete construction of the proposed project. The analysis assumes the worst-case noise levels based on three major types of construction described in this section and as shown in Table 6-6. The actual noise levels experienced during construction would be generally lower than those given in this report. The noise levels presented here are for short periods of maximum construction activity and would occur for a limited period of time. For the majority of time, construction of the proposed project would be similar to the construction of any commercial office building or other major development.

Table 6-6. Maximum Noise Levels for Typical Construction Phases

| Scenario^a | Equipment^b | Noise Levels (Lmax) at 100 feet in dBA | Noise Levels (Leq(8)) at 100 feet in dBA |
|---|--|---|---|
| Clearing, grubbing earthwork and preparation | Air compressor, back hoe, generator, concrete saws, concrete breakers, jack hammers, haul trucks, loaders and utility trucks | 85–89 | 78–82 |
| Building Construction, track installation and Paving | Paver, crane, concrete pumps, haul trucks, concrete mixer, air compressor, backhoe, generator, tractor trailer, jack hammer, pneumatic tools, utility trucks and welders | 81–86 | 74–79 |
| Miscellaneous activities | Air compressors, backhoe, crane, forklifts, haul trucks, loader, pumps, service trucks, tractor trailers, utility trucks, welders | 75–81 | 69–75 |

^a Operational conditions under which the noise levels are projected.

^b Normal equipment in operation under the given scenario.

6.5.1.1 Clearing, Grubbing, Earthwork and Preparation

Major noise-producing equipment used during the construction preparation stage could include dozers, concrete pumps, cranes, excavator, haul trucks, loader, tractor-trailers, and vibratory equipment. Maximum noise levels could reach 85 to 89 dBA within 100 feet during heavy construction activities. Other, less notable noise-producing equipment expected during this phase includes backhoes, air compressors, forklifts, pumps, power plants, service trucks, and utility trucks.

6.5.1.2 Building Construction, Track Installation and Paving

The loudest noise sources in use during this phase of construction would include cement mixers, concrete pumps, cranes, pavers, haul trucks, and tractor-trailers. The cement mixers, cranes, and concrete pumps would be required for construction of shops, buildings and the light rail alignment for facility access. The pavers and haul trucks would be used to provide the final surface on roadways and parking areas. Maximum noise levels could reach 86 dBA at 100 feet for short periods.

6.5.1.3 Miscellaneous Activities

Following the heavy main facility construction, general supporting construction such as installation of rails, and overhead power systems, shop and LRV wash facility components along with other general construction activities would still need to occur. These less intensive activities are not expected to produce noise levels above 81 dBA at 100 feet except during rare occasions, and even then only for short periods of time.

6.5.1.4 Pile Driving

The potential exists for pile driving at all of the build alternative sites. At the Preferred Alternative site and BNSF Modified Alternative site, pile foundations or drilled piers may be necessary to support elevated structures and bridges or provide support where the depth of fill would be substantial. Pile foundations may be necessary at the BNSF storage tracks to support structures and at the SR 520 Alternative site where substantial deep fill placement would occur or the light rail access lines would cross over underground utilities. Pile foundations or drilled piers would most likely be required in the northern and eastern parts of the Lynnwood Alternative site. Average maximum noise levels from pile driving typically range from 98 to 105 dBA Lmax at 50 feet. Because of the high noise levels, pile driving would be limited to daytime hours, and any pile driving would be required to meet the applicable construction noise regulations.

6.5.1.5 Preferred Alternative

Construction noise under the Preferred Alternative is not predicted to be a major concern because the majority of nearby existing land uses are commercial or industrial. All residential land uses are shielded from the site, and located more than 200 to 300 feet from most major construction activities. During the first two phases, noise from construction would be noticeable at the hospital and many of the surrounding businesses. Pile foundations or drilled piers may be necessary to support structures and bridges or in areas where the depth of fill placement would be substantial.

Construction noise levels at the Seattle Children's Hospital: Bellevue Clinic and Surgery Center were predicted for the two construction phases with the highest overall noise levels. The potential worst-case noise levels from different locations at the Preferred Alternative site and access tracks are provided in Table 6-7. The Leq(8), used for comparison with the FTA guidelines, is an 8-hour Leq that was predicted under the assumption that construction equipment is operating under full load for 4 hours of the 8-hour period, with general background construction noise levels during the other 4 hours. Construction noise at Seattle Children's Hospital: Bellevue Clinic and Surgery Center is estimated to be below the FTA recommended level of 80 dBA Leq(8) during daytime hours for residential uses unless pile driving is required.

Table 6-7. Typical Maximum Construction Noise Levels at Seattle Children's Hospital: Bellevue Clinic and Surgery Center

| Preferred Alternative Construction Phase | Access Track Construction ^a | General Site Construction ^b | OMSF Building Construction ^c |
|--|--|--|---|
| Clearing, grubbing earthwork, and preparation | 78–84 dBA Lmax 72–78 dBA Leq(8) | 64–70 dBA Lmax 60–67 dBA Leq(8) | 61–67 dBA Lmax 58–64 dBA Leq(8) |
| Building construction, track installation and paving | 74–79 dBA Lmax 72–78 dBA Leq(8) | 64–70 dBA Lmax 60–67 dBA Leq(8) | 61–67 dBA Lmax 58–64 dBA Leq(8) |

Source: U.S. Department of Transportation 1977.

a. Assuming construction activities as close as 150 feet to the hospital.

b. Assuming construction activities as close as 800 feet to the hospital.

c. Assuming construction activities as close as 1,100 feet to the hospital.

dBA = a-weighted decibels

Lmax = Maximum noise levels during periods of high activity

Leq(8) = 8 hour Leq for comparison to the FTA guidelines

6.5.1.6 BNSF Modified Alternative

Construction noise under the BNSF Modified Alternative would be the same as stated for the Preferred Alternative.

6.5.1.7 SR 520 Alternative

Construction noise under the SR 520 Alternative would be noticeable at most nearby businesses and similar to the construction noise that occurred during construction of most of the nearby commercial structures. No residences are predicted to experience adverse effects during construction of the OMSF along SR 520.

6.5.1.8 Lynnwood Alternative

For the Lynnwood Alternative, there are residences along 52nd Avenue W that are less than 100 feet from the Lynnwood Alternative site. There would be brief periods of time when noise levels could reach the maximum level of 92 dBA; however, this is unlikely to occur, except when construction would be directly adjacent to 52nd Avenue W. The highest noise levels would occur during the first two phases of construction (Table 6-7). Once those phases are completed, the final phase of construction would not be expected to produce noise levels that would be notably higher than the existing ambient noise levels the majority of time.

6.5.1.9 Nighttime Construction

Given the location of the proposed build alternative sites, it is unlikely that prolonged periods of nighttime construction would be required for any of the OMSF sites. Construction activities might be required during nighttime hours because of the nature of the construction. To perform construction at night, a construction noise permit or variance from the local jurisdictions would be required. Sound Transit and/or the contractor would be required to obtain such approvals.

6.5.2 Construction Vibration

Construction related vibration would be essentially the same under all alternatives and design options. Vibration associated with general construction activities can result in short-term increased vibration levels at nearby structures. Project-related vibration sources include soil compactors, dozers, excavators, haul trucks, flatbed tractor-trailers, backhoes, cranes, and jackhammers. The vibration sources associated with the project, even though they could be noticeable to residents when construction is nearby, are not expected to cause any structural damage.

Vibration levels for construction activities are projected to be the highest during demolition activities and soil compacting. Major construction equipment that would be used during demolition includes excavators, haul trucks, backhoes, jackhammers, and cranes. Based on information from the U.S. Bureau of Mines, it typically takes vibration levels in excess of 0.5 inches per second (in/sec) to cause cosmetic damage to plaster walls, and 0.75 in/sec for cosmetic damage to drywall. Vibration levels from project construction are projected to remain below 0.5 inches per second (in/sec) at residences along the project corridor due to the distance between the work zones and structures. Based on this projection, there is only a minimal potential for any structural damage during normal construction activities, and only for structures located within 25 to 50 feet from the work zones.

Pile driving and vibratory rollers produce some of the highest levels of vibration. Typical vibration levels from a vibratory rollers can exceed 90 to 94 VdB at 25 feet. Vibration levels from impact pile drivers frequently exceed 100 to 104 VdB at 25 feet under normal operations. Table 6-8 provides vibration levels for several different common pieces of construction equipment.

Construction vibration at Seattle Children's Hospital: Bellevue Clinic and Surgery Center is predicted to remain below the 60 VdB criteria during the majority of construction activities. During periods of heavy construction activities, such as vibratory rolling and pile driving, vibration levels at the hospital could exceed the 60 VdB criteria. Potential mitigation for vibration at the Seattle Children's Hospital: Bellevue Clinic and Surgery Center is provided in section 7.5.3.

Table 6-8. Vibration Levels for Typical Construction Equipment

| Equipment | Conditions | Peak Particle Velocity at 25 feet (in/sec) | Vibration Level in VdB at 25 feet (re 1 micro-in/sec) |
|--|-------------------|---|--|
| Large Bulldozer | Normal operations | 0.089 | 87 |
| Loaded haul trucks | Normal operations | 0.076 | 86 |
| Jackhammer | Normal operations | 0.035 | 79 |
| Small Bulldozer | Normal operations | 0.003 | 58 |
| Vibratory Roller | Normal operations | 0.210 | 94 |
| Pile Driver (Impact) | Normal operations | 0.644 | 104 |
| Source: Federal Transit Administration 2006. in/sec = inches per second; VdB = velocity decibels. | | | |

This section describes the potential noise and vibration mitigation measures that could be used for the build alternatives. However, if during final design Sound Transit determines that the relevant noise criterion could be achieved by a less costly means, or that the noise or vibration impact at that location would not occur even without mitigation, then the mitigation measure would be eliminated or modified as needed. Conversely, if any additional noise impacts are identified during final design or after operations begin, then Sound Transit would provide mitigation that is necessary and appropriate under Sound Transit policies and FTA and local noise standards.

7.1 No Build Alternative

Under the No Build Alternative, there would be no project and no noise mitigation would be required.

7.2 Preferred Alternative

An exceedance of the City of Bellevue Noise Control Ordinance would occur at the property line at the north end of the existing Metro bus storage and maintenance base. The affected location would be directly across from the LRV wash, an area where buses are stored. This area is not noise sensitive. In addition, the exceedance would not occur at the facility's office buildings. This impact occurs for two reasons. First, the OMSF is designated an EDNA B, although the OMSF is industrial in nature and would typically be designated an EDNA C. Furthermore, the bus storage is also designated an EDNA B, but it too is an industrial land use and would typically be classified EDNA C. If either of these facilities were designated EDNA C, there would be no noise impact.

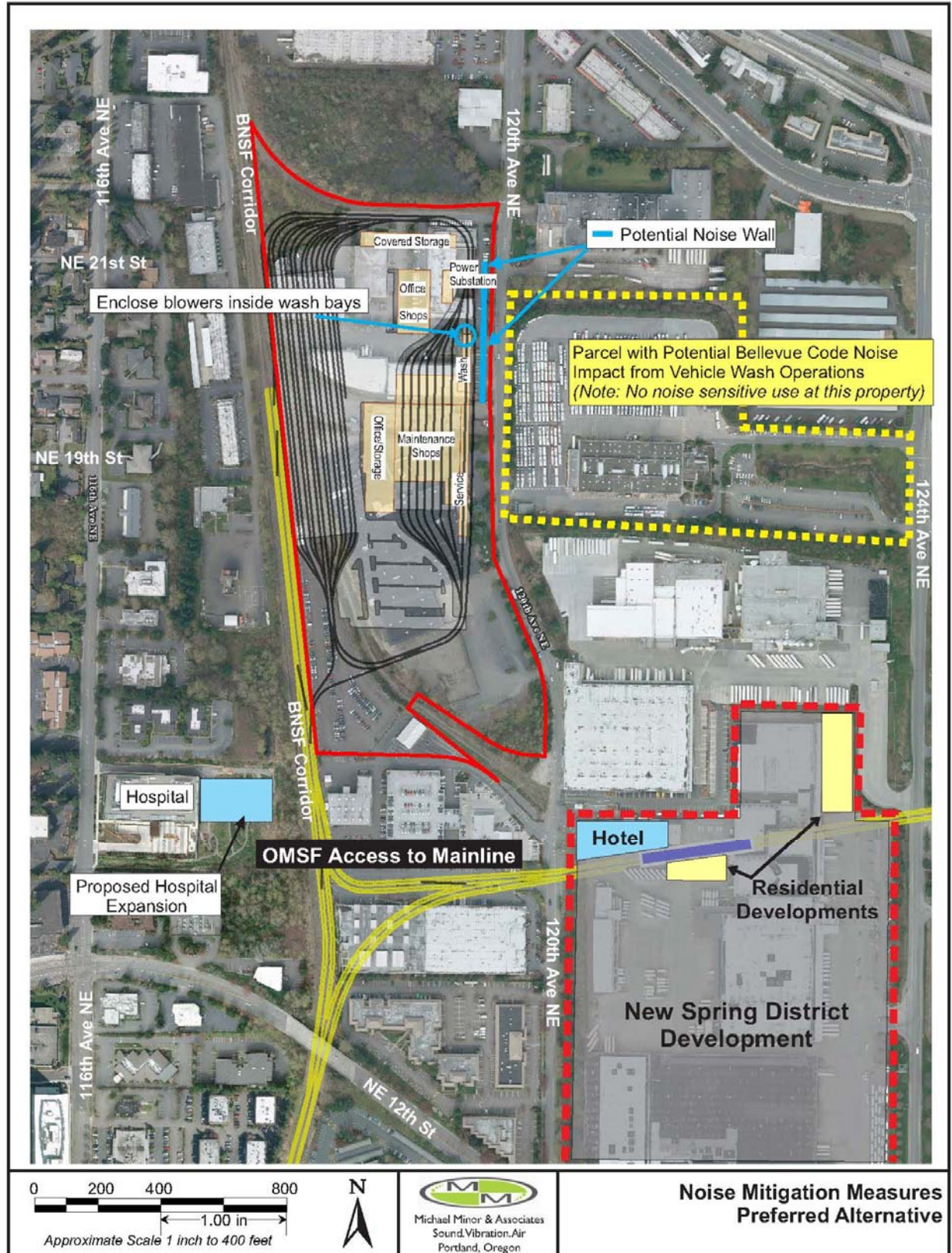
Sound Transit would reduce noise from the blowers to the existing Metro bus storage and maintenance base levels by 5 to 12 dB, by either:

- Extending the length of the wash facility to enclose the blowers within the wash bays; or
- Installing a noise barrier along the east side of the wash area, length to be determined, covering the end of the wash bays. The noise barrier could be integrated into the wash building design.

The final noise mitigation solution would be determined during the final design process, after the building design and location of the blowers are finalized and additional information can be obtained from car wash manufacturers, who may be able to provide alternative-noise reducing measures for the blowers that could be used in place of those proposed in this report. Figure 7-1 shows the approximate location of the mitigation measures, with the actual length of the noise wall being determined during final design.

There would be no vibration impacts; therefore, no vibration mitigation is necessary.

Figure 7-1. Preferred Alternative—Noise Mitigation Measures



7.3 BNSF Modified Alternative and SR 520 Alternative

No FTA criteria or local code noise or vibration impacts were identified under the BNSF Modified Alternative or SR 520 Alternative.

7.4 Lynnwood Alternative

Under the Lynnwood Alternative, noise impacts were identified at 19 EDNA Class A residences. These impacts would be located along 52nd Avenue W and be mainly due to LRV wash operations and train movements at night. Mitigation for the Lynnwood Alternative would use the same automated door system for the LRV wash that was described for the Preferred Alternative. In addition, a noise wall would be installed along 52nd Avenue W, on the west side of the Lynnwood Alternative site, between the OMSF and the residences to the west. Because no noise impacts due to train movement and the maintenance bays would occur north of 204th Street SW, the noise wall would be required to reduce noise north of 204th Street. Overall noise levels at affected homes could be reduced by 10 to 13 dB with use of an acoustical noise wall along 52nd Avenue W. The OMSF noise levels would also be reduced by 6 to 11 dBA at residences farther away from the OMSF that would not have noise impacts but would nonetheless receive a benefit from the proposed mitigation. Noise levels for the 19 impacts, with and without mitigation, are shown on Table 7-1. The locations of the automated wash bay doors and proposed noise wall are shown in Figure 7-2.

No vibration impacts were projected for the Lynnwood Alternative; therefore, no vibration mitigation is recommended.

Table 7-1. Lynnwood Alternative Noise Mitigation Analysis Results

| Address ^a | Project Noise (Leq in dBA) ^b | Noise Impacts ^c | Project w/Mitigation (Leq in dBA) ^d | Impacts w/Mitigation ^e | Mitigation Methods ^f |
|--|---|----------------------------|--|-----------------------------------|---------------------------------|
| 5211 208th St SW | 50 | 0 | 38 | 0 | Acoustical noise wall |
| 20706 52nd Ave W | 53 | 1 | 42 | 0 | Acoustical noise wall |
| 20628 52nd Ave W | 54 | 1 | 43 | 0 | Acoustical noise wall |
| 20624 52nd Ave W | 55 | 1 | 43 | 0 | Acoustical noise wall |
| 20618 52nd Ave W | 55 | 1 | 44 | 0 | Acoustical noise wall |
| 5210 206th St SW | 57 | 1 | 45 | 0 | Acoustical noise wall |
| 20526 52nd Ave W (Cedar Valley Grange) | 61 | 1 | 49 | 0 | Acoustical noise wall |
| 20504 52nd Ave W | 59 | 1 | 47 | 0 | Acoustical noise wall |
| 20430 52nd Ave W | 57 | 1 | 46 | 0 | Acoustical noise wall |
| 20416 52nd Ave W | 54 | 1 | 43 | 0 | Acoustical noise wall |
| 20410 52nd Ave W | 55 | 1 | 45 | 0 | Acoustical noise wall |
| 20406 52nd Ave W | 55 | 1 | 45 | 0 | Acoustical noise wall |
| 5207 204th St | 55 | 1 | 45 | 0 | Acoustical noise wall |
| 20316 52nd Ave W | 55 | 1 | 44 | 0 | Acoustical noise wall |
| 20306 52nd Ave W | 53 | 1 | 43 | 0 | Acoustical noise wall |
| 20302 52nd Ave W | 52 | 1 | 41 | 0 | Acoustical noise wall |

| Address^a | Project Noise (Leq in dBA)^b | Noise Impacts^c | Project w/Mitigation (Leq in dBA)^d | Impacts w/Mitigation^e | Mitigation Methods^f |
|----------------------------|---|----------------------------------|--|---|---------------------------------------|
| 20220 52nd Ave W | 49 | 0 | 39 | 0 | Acoustical noise wall |
| 20505 53rd Ave W | 49 | 0 | 38 | 0 | Acoustical noise wall |
| 20511 53rd Ave W | 54 | 1 | 43 | 0 | Acoustical noise wall |
| 20517 53rd Ave W | 57 | 1 | 45 | 0 | Acoustical noise wall |
| 20523 53rd Ave W | 51 | 1 | 38 | 0 | Acoustical noise wall |
| 20601 53rd Ave W | 45 | 1 | 39 | 0 | Acoustical noise wall |
| 20609 53rd Ave W | 44 | 0 | 37 | 0 | Acoustical noise wall |
| Scriber Creek Park | 47 | 0 | 47 | 0 | N/A |

Sites shown in Figure 7-2.

City of Lynnwood Noise Control Ordinance for EDNA Class A (residential) noise levels is 60 dBA Leq (daytime) and 50 dBA Leq at night.

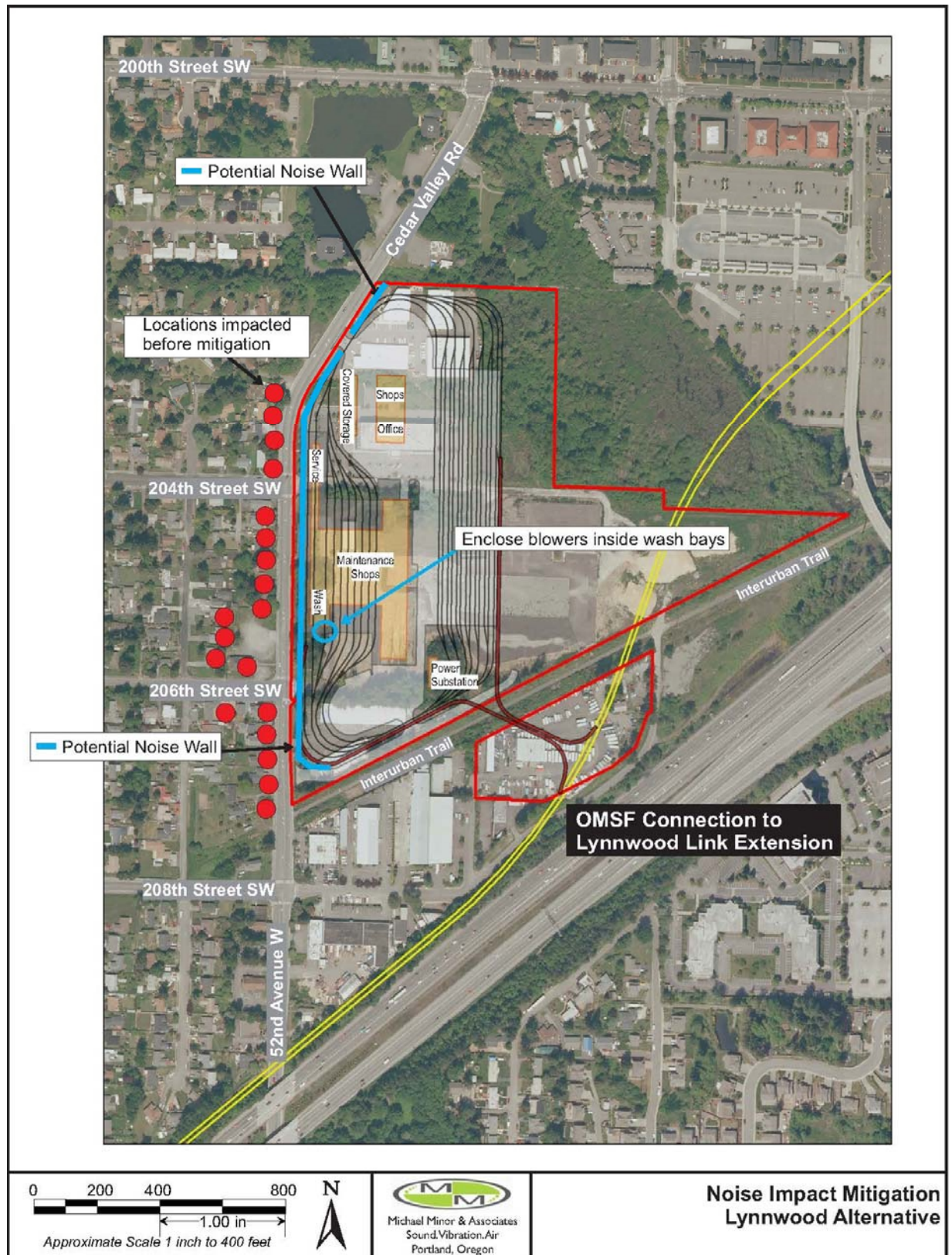
Number of homes with noise levels above the criteria without mitigation.

Project noise levels with proposed noise mitigation measures.

Number of homes with noise levels above the criteria with noise mitigation measures.

Type of mitigation proposed for the project impact (N/A = no mitigation was applicable to this site).

Figure 7-2. Lynnwood Alternative—Noise Mitigation Measures



7.5 Construction Mitigation

Under Sound Transit's Light Rail Noise Mitigation Policy, Sound Transit would seek to limit construction noise levels and meet applicable noise regulations and ordinances. Typical mitigation measures that could be applied are discussed below. Contractors would be required to meet the criteria of the noise ordinances of the Cities of Bellevue and Lynnwood.

7.5.1 Noise Mitigation

Several noise-mitigation measures could be implemented to reduce construction noise levels to within the required limits. Sound Transit would, as practical, limit construction activities that produce the highest noise levels during daytime hours, or when disturbance to sensitive receivers would be minimized. For operation of construction equipment that could exceed allowable noise limits during nighttime hours (between 10 p.m. and 7 a.m.) or on Sundays or legal holidays, Sound Transit would obtain the appropriate construction noise permit or variance from the Cities of Bellevue or Lynnwood.

Noise-control mitigation could include the following measures, as necessary, to meet required noise limits:

- Use low-noise emission equipment.
- Use broadband backup warning devices on all vehicles.
- Implement noise-deadening measures for truck loading and operations.
- Conduct monitoring and maintenance of equipment to meet noise limits.
- Use acoustic enclosures, shields, or shrouds for equipment and facilities.
- Install high-grade engine exhaust silencers and engine-casing sound insulation.
- Minimize the use of generators.
- Prohibit impact pile driving during nighttime hours.
- Use movable noise barriers at the source of the construction activity.

7.5.2 Construction Vibration Mitigation

Building damage from construction vibration is not anticipated for the proposed project due to the type of construction and distance between the site and any nearby properties.

Sound Transit would coordinate with Seattle Children's Hospital: Bellevue Clinic and Surgery Center prior to construction of the Preferred Alternative, BNSF Modified Alternative, or the BNSF Storage Tracks component of the Lynnwood Alternative to confirm the type and location of vibration-sensitive equipment within the building. If necessary, mitigation measures would be developed by Sound Transit, such as construction vibration monitoring with a notification system and coordination of the construction schedule with the hospital.

Chapter 8

Indirect and Cumulative Analysis

This chapter provides a summary of the indirect and cumulative noise levels expected once the light rail extension and OMSF facilities are completed. For example, under the Preferred Alternative, this analysis provides a review of potential total noise from light rail operations in combination with the noise from operation of the OMSF. The cumulative analysis also assumes that any noise mitigation measures proposed for the East Link and Lynnwood Link Extension would be constructed with the project. Potential indirect impacts due to future development scenarios adjacent to and over portions of the OMSF are also considered for the Preferred Alternative. Building design considerations and/or recommendations are provided to address issues related to the compatibility of such scenarios with the OMSF.

8.1 Preferred Alternative

Under the Preferred Alternative, cumulative noise levels for properties near this alternative site would be similar to the noise levels given for the proposed project alone. Depending on the location of the receiver, there is potential for slightly increased noise from TOD-related activities. Conversely, some sites, which may receive some structural shielding, could see slight reductions in the overall noise levels. In addition, operational noise levels along the selected East Link alignment would be the same as those provided in the *East Link Project Final EIS* (Sound Transit 2011), as updated during East Link final design and permitting. The updated noise analysis prepared as part of East Link permitting with the City of Bellevue accounts for early morning deployment of trains from the OMSF and return trips after revenue service ends. The current operating plan for early-morning non-revenue service trips would be the same regardless of which OMSF build alternative is selected. Because the location of the East Link project is several hundred feet from all of the OMSF build alternative sites, noise from the light rail would not add to the projected noise from the OMSF. Therefore, no cumulative noise impacts are projected under this alternative.

Cumulative construction noise generated at the properties near the Preferred Alternative would be the same as described under the construction section. The potential exists for some other local construction projects to overlap with construction of this project. This would happen only if other unrelated construction projects occur simultaneously with this project. However, because the proposed OMSF project's construction noise analysis assumes the worst-case noise levels, the overall maximum noise levels at any one property would remain the same, as presented in Chapter 7, *Mitigation*.

8.1.1 Future Conceptual Development

Conceptual future development scenarios at the Preferred Alternative site were developed. The potential development scenarios represent a conceptual capacity analysis, which was based on available space and zoning at the Preferred Alternative site. The site layout for the Preferred Alternative would allow up to five parcels to be available for potential future development, with roadway access to 120th Avenue NE.

The potential development scenarios include multiuse buildings with residential, commercial, and retail uses. Noise associated with these types of developments include increased traffic, noise from ventilation and air conditioning units, maintenance of the new facilities, deliveries, and general activities associated with residential, commercial, and retail land uses. Construction of new buildings would also contribute to the noise environment temporarily.

8.2 BNSF Modified Alternative

Under the BNSF Modified Alternative, cumulative noise levels at properties near to the BNSF Modified Alternative site would be similar to those given for the OMSF in Chapter 7, *Mitigation*, for properties near the proposed site, and noise levels along the East Link alignment would be the same as provided in the *East Link Project Final EIS* (Sound Transit 2011), as updated through ongoing mitigation design and noise studies supporting East Link final design and permitting. Noise from the BNSF Modified Alternative site would not contribute to the mainline East Link light rail noise because the alignment is more than 600 feet south of the BNSF Modified Alternative site.

Cumulative construction noise generated at the properties near the BNSF Modified Alternative site would be the same as described for the Preferred Alternative.

8.3 SR 520 Alternative

Under the SR 520 Alternative, cumulative noise levels at properties near to the SR 520 Alternative site would be similar to those given for the OMSF in Chapter 7, *Mitigation*, for properties near the site, and noise levels along the East Link alignment would be the same as provided in the *East Link Project Final EIS* (Sound Transit 2011), as updated through ongoing mitigation design and noise studies supporting East Link final design and permitting. Noise from the SR 520 Alternative site would not contribute to the mainline East Link noise because the alignment is approximately 500 feet southeast of the SR 520 Alternative site.

Cumulative construction noise generated at the properties near the SR 520 Alternative site would be the same as described for the Preferred Alternative.

8.4 Lynnwood Alternative

Under the Lynnwood Alternative, cumulative noise levels at properties near to the Lynnwood Alternative site would be similar to those given for the OMSF in Chapter 7, *Mitigation*, for properties near the proposed site along 52nd Avenue W, and noise levels along the Lynnwood Link Extension alignment would be the same as provided in the *Lynnwood Link Extension Final EIS* (Sound Transit 2015). Noise from the OMSF would not contribute to the Lynnwood Link light rail mainline noise because the alignment is more than 400 feet south of the Lynnwood Alternative site, is shielded from the 52nd Avenue W residences by existing and future structures, and is along I-5.

Cumulative construction noise generated at the properties near the Lynnwood Alternative would be the same as described under the construction section. The potential exists for some other local construction projects to overlap with construction of the proposed project. This would happen only if other unrelated construction projects occur simultaneously with this project. However, because

the proposed OMSF project's construction noise analysis assumes the worst-case noise levels, the overall maximum noise levels at any one property would remain the same, as presented in Chapter 7, *Mitigation*.

Chapter 9

References

- Federal Transit Administration (FTA). 2006. *Transit Noise and Vibration Impact Assessment: Guidance Manual*. Report FTA-VA-90-1003-06. Prepared by Harris Miller Miller & Hanson, Inc. Burlington, MA. Federal Transit Administration, Washington D.C. May
- Sound Transit. 2003. *Noise and Vibration Technical Report, Seattle Link Light Rail Project*. Seattle, Washington.
- . 2011. *East Link Project Final Environmental Impact Statement*. Prepared by North Corridor Transit Partners, Seattle, WA. Prepared for Sound Transit, Seattle, WA.
- . 2013. *Lynnwood Link Extension Draft Environmental Impact Statement*. Prepared by North Corridor Transit Partners, Seattle, WA. Prepared for Sound Transit, Seattle, WA.
- U.S. Department of Transportation (USDOT). 1977. *Highway Construction Noise: Measurement, Prediction and Mitigation*. U.S. Department of Transportation. Federal Highway Administration, Washington, DC.
- . 2006. *FHWA Roadway Construction Noise Model User's Guide*. U.S. Department of Transportation. Federal Highway Administration. Washington D.C.

